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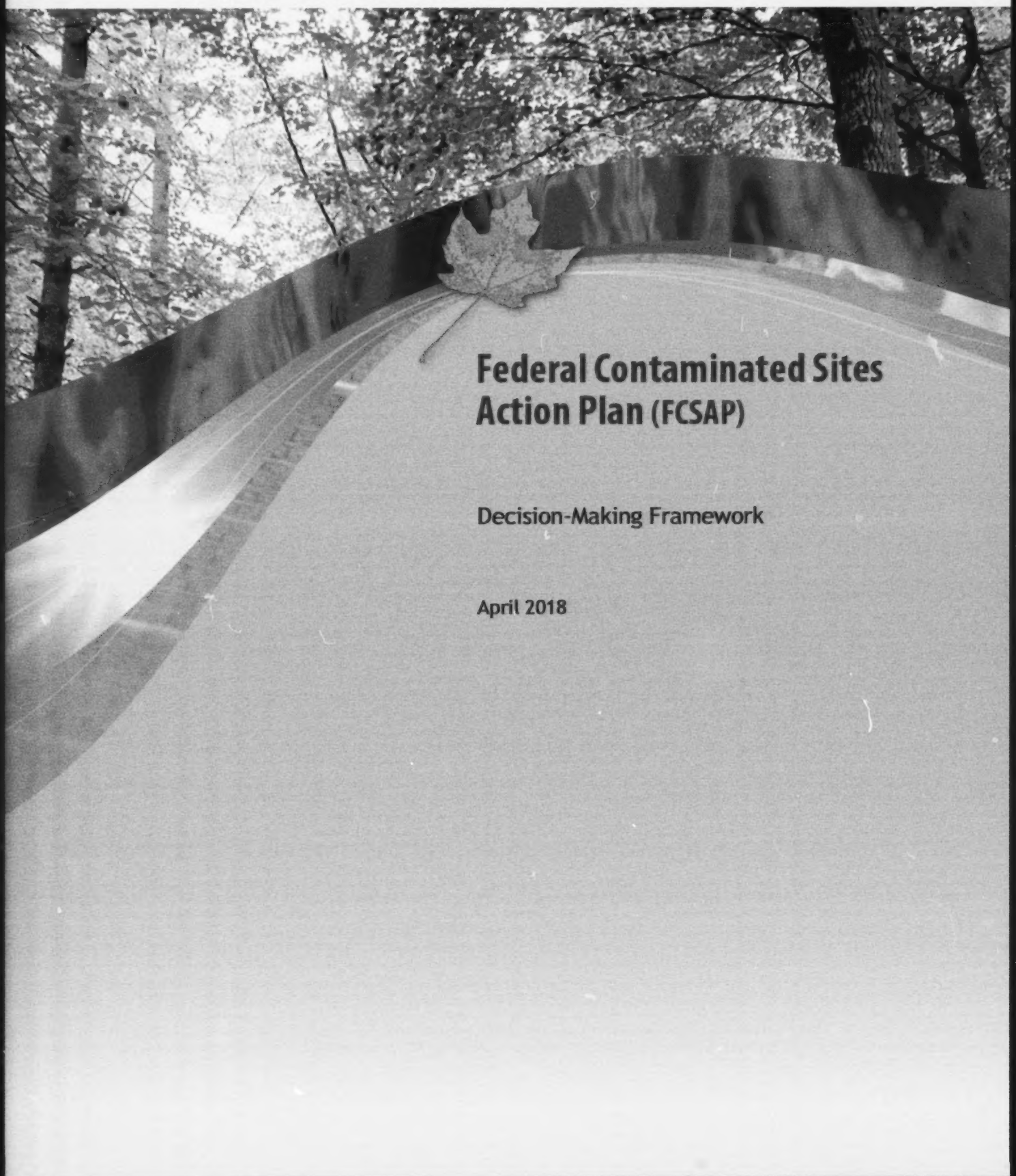

Federal Contaminated Sites Action Plan (FCSAP)

Decision-Making Framework

April 2018

Federal Contaminated Sites Action Plan (FCSAP) Decision-Making Framework (DMF)

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Document change control

Revision Number	Date of Issue	Author(s)	Brief Description of Change
1.0	May 22, 2013	Systemscope	Document created
2.0	March 31, 2015	Systemscope	Document updated with climate change and sustainability information. References have also been updated.
3.0	April 19, 2018	FCSAP Secretariat	Sustainability text (in text and Appendix A) was revised and Appendix A is now linked as a separate document. In text references and the bibliography have also been updated.
3.1	April 9, 2018	FCSAP Secretariat	Appendix A has been added to this document.

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Decision-Making Framework (DMF)

What is the Federal Contaminated Sites Action Plan (FCSAP)?

Federal Contaminated Sites Action Plan (FCSAP) is a 15-year program that was established in 2005 with funding of $3.5 billion from the Government of Canada.

The primary objective of the FCSAP program is to reduce environmental and human health risks from known federal contaminated sites and associated federal financial liabilities. The program provides site assessment funding as well as remediation/risk management funding to custodians for FCSAP eligible sites. It also provides technical expert support staff to all custodians managing a contaminated site. As part of the program's primary objective, guidance materials such as this Decision-Making Framework (DMF) are developed to provide detailed information to all custodians managing contaminated sites, regardless of the site's FCSAP funding eligibility. For more FCSAP and other contaminated sites management guidance materials please contact the FCSAP Secretariat at Environment and Climate Change Canada (FCSAP.PASCF@ec.gc.ca) or consult the reference lists at the end of each section in this DMF.

What is the Decision-Making Framework (DMF)?

The Decision-Making Framework (DMF) for the FCSAP is a roadmap that outlines the specific activities and requirements for addressing federal contaminated sites in Canada. The DMF is based on *A Federal Approach to Contaminated Sites*, a 10-step process guiding federal custodians in all aspects of working with contaminated sites. The 10-step process was developed to provide a common approach to managing contaminated sites for which the federal government is responsible. The DMF does not replace the 10-step process; rather, it is a complementary guide to assist federal custodians in managing their contaminated sites by providing guidance on key decisions at each step of the federal approach. Custodians are encouraged to consult *A Federal Approach to Contaminated Sites* (CSMWG, 1999), as they navigate through the DMF to obtain more details at each step.

The DMF is broken into individual segments that make it easier to understand each step. It enables custodians to consider the critical decisions they have to make at each step and helps them understand how and when the expert support departments can help them in decision making. By clarifying the rules to be followed under the FCSAP, this guide also increases consistency in the decision-making process and improves the effectiveness of site assessment and remediation activities.

This updated version of the DMF now provides guidance to custodians on how to improve the sustainability of their site assessment and remediation/risk management activities, and to incorporate climate change considerations throughout their contaminated site management plan.

The sustainability measures integrated into this document are based on the FCSAP's Sustainability Strategy in which custodians are encouraged to consider sustainable options and weigh the impacts of contaminated sites management on social, financial and environmental aspects. General guidance is also provided within the document on identifying site specific climate change impacts.

All acronyms used in this document are explained in the List of Abbreviations and all references are listed in the Reference List.

How to use the DMF

To ensure consistency and ease of use, each of the 10 steps is described using the same page format:

- A general description of the step, including key decisions to be made by custodians.
- A flowchart showing the main management options available at each step, allowing users to visualize the different avenues and decision points available.
- An explanation of the services offered to the custodians by the expert support departments and FCSAP Secretariat.
- All relevant supporting documentation and tools.

Disclaimer

Although the guidance provided in the DMF is intended to meet the needs of most scenarios, professional judgment is required throughout the process.

The 10-step process

Step 1: Identify Suspect Site

Step 2: Historical Review

Step 3: Initial Testing Program

Step 4: Classify Site (optional)

Step 5: Detailed Testing Program

Step 6: Re-Classify Site

Step 7: Develop Remediation/Risk Management Strategy

Step 8: Implement Remediation/Risk Management Strategy

Step 9: Confirmatory Sampling and Final Reporting

Step 10: Long-Term Monitoring (if required)

Supporting documents and tools useful throughout the 10-step process

These are documents and tools that may be of value to a custodian throughout the 10-step process. Custodians should also refer to the IDEA secure website and the step-specific reference lists found at the end of each step in this DMF.

Legislation/Policy

- Policy on Management of Real Property (TBS, 2006)
- Reporting Standard on Real Property (TBS, 2006)

Guidance

- Guidance Document on the Management of Contaminated Sites in Canada (CCME, 1997)
- A Federal Approach to Contaminated Sites (CSMWG, 1999)
- Project/Program Risk Management Guidance for Federal Contaminated Sites Remediation/Risk Management (R/RM) Projects (PSPC, 2007)
- FCSAP Guidance Manual (FCSAP, 2008)
- Directive on Contingencies (TBS, 2009)
- Framework for Addressing and Managing Aquatic Sites under the Federal Contaminated Sites Action Plan (FCSAP, 2011)
- Guide to the Management of Real Property (TBS, 2011)
- Eligible Costs Guidance, ver. 5.0 (FCSAP, update in progress)
- Federal Contaminated Sites Inventory (FCSI) Mini-Guide , v. 2 (TBS, 2014)
- Projects Near Water (website) (DFO, 2015)

Other

- Federal Contaminated Sites Inventory (FCSI) Input Guide (TBS, 2016)
- Waves: Fisheries and Oceans Canada Library (website) (DFO, 2014)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)

Step 1: Identify Suspect Site

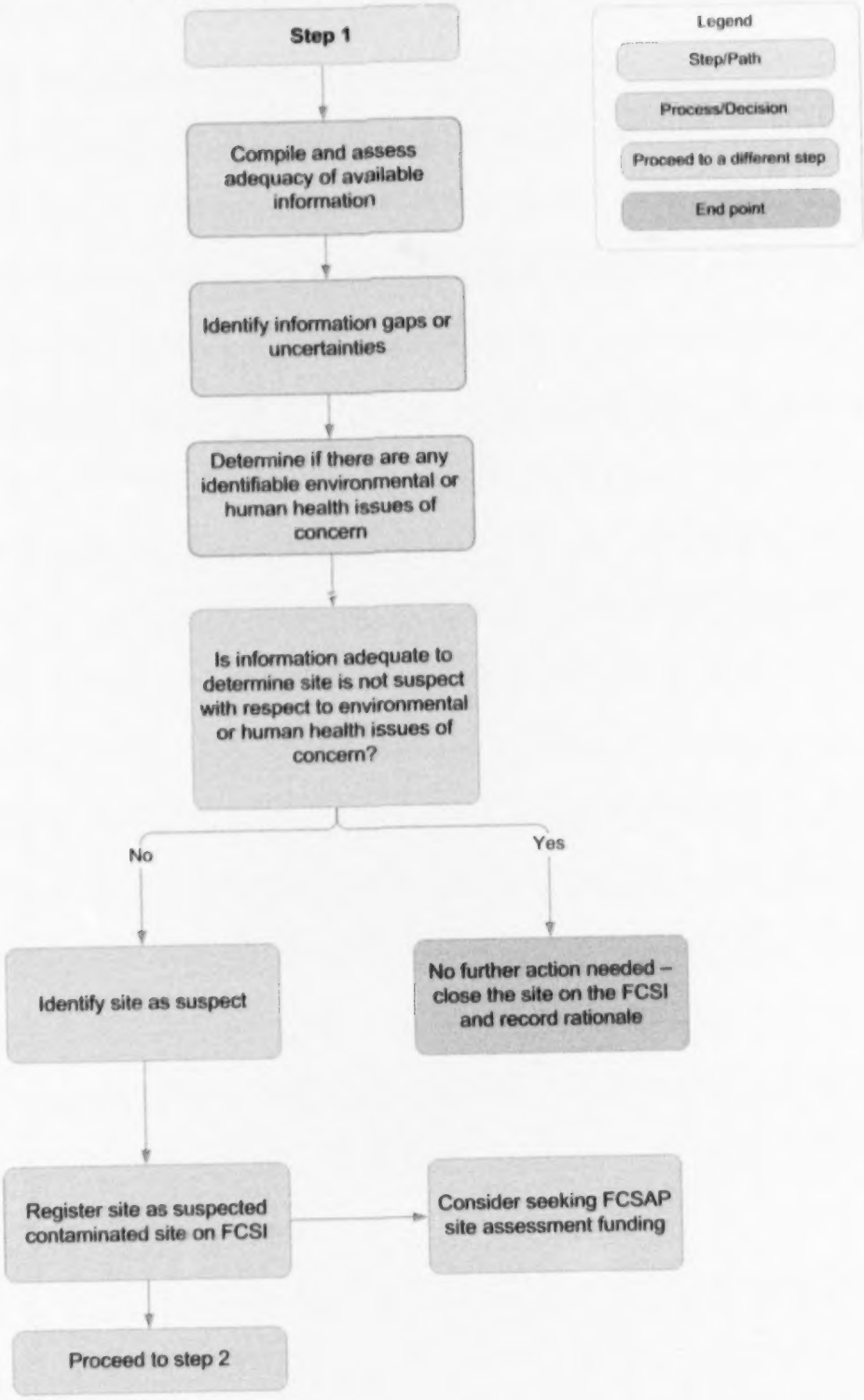
Step 1 is the identification of a potentially contaminated site, called a "suspected site," based on past or current activities that have occurred on or near the site. This step involves compiling and reviewing past and current land uses, activities, and information about a site in order to determine whether there is a potential risk to human health and/or the environment that requires further investigation.

At this step, and throughout the 10-step process, custodians need to consider the interests of stakeholders—in other words, those interested in and affected by the site. Health Canada (HC) guidance documents for public involvement need to be reviewed at this step.

Key decision(s):

- Determine whether no further action is required or if the site should be identified as suspected and proceed to Step 2 (Historical Review).
- If a site is suspected, consider seeking FCSAP site assessment funding.
- Identify stakeholders and public involvement needs.

Step 1: Identify Suspect Site


Step 1
Compile and assess adequacy of available information
Identify information gaps or uncertainties
Determine if there are any identifiable environmental or human health issues of concern
Is information adequate to determine site is not suspect with respect to environmental or human health issues of concern?
No
Yes
Identify site as suspect
No further action needed – close the site on the FCSI and record rationale
Register site as suspected contaminated site on FCSI
Consider seeking FCSAP site assessment funding
Proceed to step 2
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

Consider seeking Federal Contaminated Sites Action Plan (FCSAP) assessment funding

At this step, custodians can apply for FCSAP site assessment funding (the site assessment takes place from Step 1 to 6) if the site is on federal lands, or on non-federal lands for which the federal government has accepted full responsibility, and there are documented reasons for suspecting that a site is contaminated from activities that occurred prior to April 1, 1998. Custodians are required to submit assessment proposals to the FCSAP Secretariat but must demonstrate the priority of the site receiving FCSAP site assessment funding in a risk-based manner using the Priority for Assessment Tool (PAT) (FCSAP, update in progress) or an equivalent system.

How Fisheries and Oceans Canada (DFO) expert support can assist

- Identify:
    - fish and fish habitat concerns on or near the site;
    - aquatic species listed under the *Species at Risk Act* (SARA) (2002); and
    - additional information requirements.
- Provide information on past DFO involvement at the site (studies, Fisheries Act authorizations, letters of advice, etc.).
- Provide advice on DFO regulatory responsibilities and processes.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice on known risks to the environment in the site area and impacts that may have occurred from past operations conducted at the site.
- Provide advice on ECCC regulatory responsibilities and processes.

How Health Canada (HC) expert support can assist

- Provide advice on identifying human health concerns on the site, or off-site issues related to contamination at the site based on historical activity, including the identification of additional information required to delineate contamination and adequately assess human health risks.
- Provide training and/or guidance on public involvement and advice on the implementation of an effective public involvement strategy.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice on determining if site requires further investigation and what scope of further investigation may include, such as cost and time frame estimates.

How the FCSAP Secretariat can assist

- Provide advice on the FCSAP process and eligibility for funding.

Supporting documents and tools specific to Step 1

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Legislation

- Canada Wildlife Act (1985)
- Fisheries Act (1985)
- Migratory Birds Convention Act (1994)
- Species at Risk Act (SARA) (2002)

General Guidance

- Addressing Psychosocial Factors through Capacity Building: A Guide for Managers of Contaminated Sites (HC, 2005)
- Improving Stakeholder Relationships: Public Involvement and the Federal Contaminated Sites Action Plan (FCSAP): A Guide for Site Managers (HC, 2006)
- A Guide to Involving Aboriginal Peoples in Contaminated Site Management (HC, 2010)
- Supplemental Guidance on Developing a Contract Statement of Work for Human Health Preliminary Quantitative Risk Assessment (PQRA) and Detailed Quantitative Risk Assessment (DQRA) (HC, 2010)
- For Human Health Risk Assessment (HHRA): Federal Contaminated Site Risk Assessment in Canada (available on request from cs-sc@hc-sc.gc.ca):
    - Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0 (HC, 2012)
    - Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0 (HC, 2010)
    - Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0 (HC, 2010)
    - Part V Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) (HC, 2010)
    - Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment ($DQRA_{RAD}$) (HC, 2010)
    - Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites (HC, 2010)
- FCSAP Statements of Work for Ecological Risk Assessments at Federal Sites (FCSAP, 2011)
- Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011)

Other

- Species at Risk Public Registry

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- Eligible Costs Guidance, 5.0 (FCSAP, update in progress)
- FCSAP Operational Guidelines (FCSAP, 2016; internal document)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)

Step 2: Historical Review

In Step 2, a suspected site identified in Step 1 undergoes a Historical Review of information, also known as a Phase I Environmental Site Assessment (ESA) and the custodial department accountable will consult with stakeholders. The four principal components of a Phase I ESA are 1) a records review; 2) a site visit; 3) interviews; and 4) an evaluation of information and reporting.

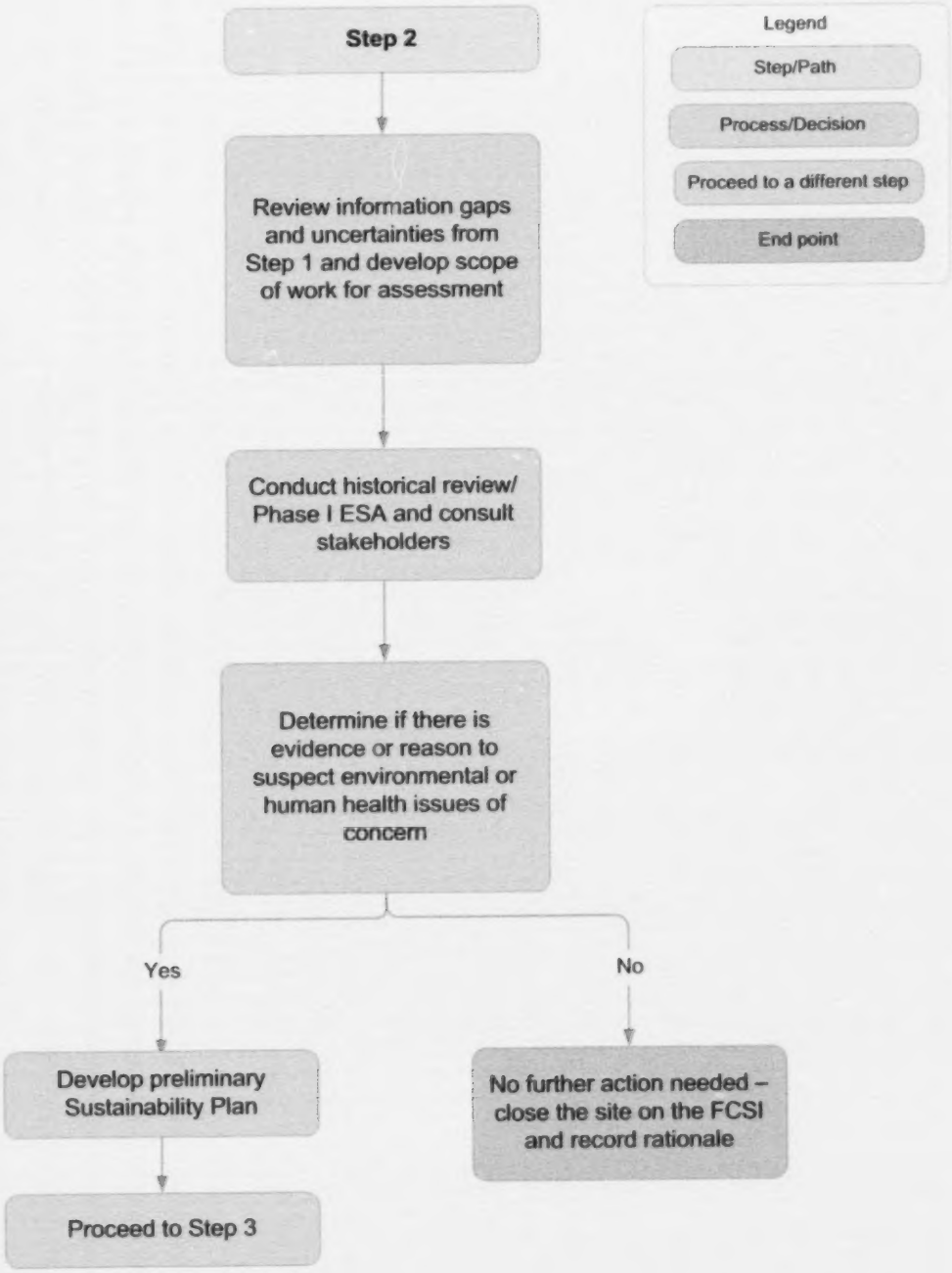
This information will provide insight into the types and locations of potential contaminants and the suspected pathways and receptors. Custodians must prioritise the sites that are being assessed (for financial capacity or prioritization of activity reasons); this can be done using the Priority for Assessment Tool (PAT) (FCSAP; update in progress) or an equivalent system. The PAT assists custodians in prioritizing assessment work by ranking sites. For FCSAP-funded site assessments, a priority assessment must be submitted to the Secretariat at some point during Step 1 to 6. Sites that are not identified as a priority for assessment should be re-evaluated periodically according to a custodian's portfolio characteristics.

If there is evidence or reason to suspect environmental or human health issues of concern, then the custodian could develop a Preliminary Sustainability Plan (see Appendix A) for the site as described in the Sustainability Strategy and Implementation guidance (Appendix A). The plan should also require any consultants and contractors working on the site to consider implementing, where feasible, elements of the Preliminary Sustainability Plan (see Appendix A).

Key decision(s):

- Validate Step 1 conclusions that there is reason to suspect that the site is contaminated and that assessment should continue to Step 3 (Initial Testing program).
- Determine whether the site can be closed because no further action is required.
- Determine whether a Preliminary Sustainability Plan should be developed and, if applicable, at which steps sustainability should be integrated.

Step 2: Historical Review


Step 2
Review information gaps and uncertainties from Step 1 and develop scope of work for assessment
Conduct historical review/ Phase I ESA and consult stakeholders
Determine if there is evidence or reason to suspect environmental or human health issues of concern
Yes
No
Develop preliminary Sustainability Plan
Proceed to Step 3
No further action needed – close the site on the FCSI and record rationale
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Provide fish, fish habitat and fisheries background information at or near the site, if available.
- Provide information on regulatory frameworks applicable to aquatic sites.
- Review the Phase I ESA (CSA, 2001) and provide advice.
- Participate in site visit activities.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP, 2011).

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide regulatory advice concerning past operations conducted at the site.
- Provide advice on site assessment standards and best practices.
- Review the Phase I ESA, identify information gaps and provide advice on information gathering.
- Participate in site visit activities.

How Health Canada (HC) expert support can assist

- Provide advice on developing a site assessment that can be used for adequately characterizing chemicals of potential concern in site media based on historical land use, which is important for assessing risks to human health and future decision making.
- Review the Phase I ESA report and provide anticipatory technical comments related to requirements for the Step 3 Phase II ESA (CSA, 2001) to identify potential human health exposure and information gaps that may require additional assessment in order to identify whether there are human health risks.
- Participate in site visit activities.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice on the Phase I ESA, including the historical review/assessment, and determine if further work is required or no further action needs to be taken.

How the FCSAP Secretariat can assist

- Provide general FCSAP program information and support.
- Provide assistance in using the Priority for Assessment Tool (PAT) (FCSAP, update in progress) and the Eligible Cost Guidance, v. 5.0 document (FCSAP, update in progress), as required.

Supporting documents and tools specific to Step 2

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

General Guidance

- Canadian Standards Association (CSA) Standards for Phase I Environmental Site Assessments (CSA, 2001)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- Eligible Costs Guidance, 5.0 (FCSAP, update in progress)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)
- Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP, 2011)

Step 3: Initial Testing Program

Step 3 involves focusing on the identified environmental issues and potential risks. An Initial Testing Program, also known as a Phase II Environmental Site Assessment (ESA) (CSA, 2004) is conducted to investigate actual site conditions, and stakeholders should be consulted. Stakeholders can provide key information about the site history and condition, end use of the site, exposure pathways, receptors, contaminants of potential concern, and safe exposure limits.

A Phase II ESA (CSA, 2004) includes six stages:

1. Planning
2. Field Investigation and Sampling
3. Sample Analysis
4. Data Interpretation and Evaluation
5. Risk Identification
6. Conceptual Site Model Development

This step will provide a preliminary assessment of the degree, nature and extent of the contamination.

In developing the scope of work and conducting a Phase II ESA (CSA, 2004), climate change effects should be considered at the ESA's Risk Identification (Stage 5) and Conceptual Site Model Development (Stage 6) stages. This involves the collection of data on climate conditions (e.g. temperature, precipitation, wind) to assist with the assessment of future predicted climate conditions.

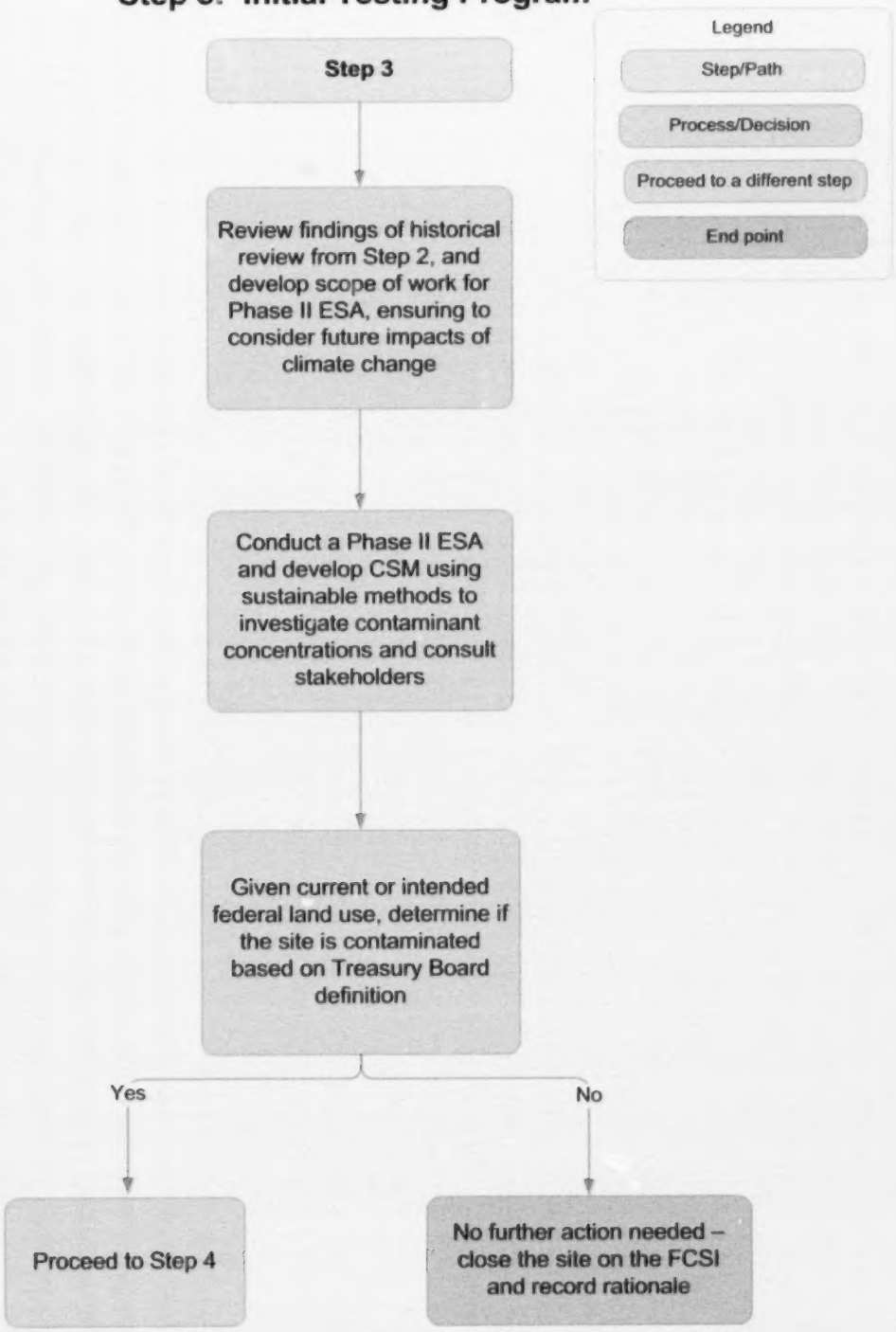
The Framework for Addressing and Managing Aquatic Sites under the FCSAP program (FCSAP, 2011) should also be consulted if aquatic ecosystems are present on the site. The Aquatic Sites Framework provides guidance on the management of aquatic sites for every step of the DMF.

ESAs should use sustainable methods that reduce energy use and waste generation, and contracting clauses encouraging the use of sustainable practices should be integrated into the procurement plan.

Key decision(s):

- Define the appropriate current or intended federal land-use scenario according to the Canadian Council of Ministers of the Environment (CCME) guidelines for land use of studied site.
- Confirm, based on the assessment results, and the current or intended land use, if the site is contaminated according to the Treasury Board of Canada (TB) definition.
- Conduct a preliminary assessment on the effects of climate change at the site and determine whether there will be any short, medium, or long-term impacts on contaminant types, concentrations, or distribution or changes in the residency media.
- Determine options for integrating sustainable practices into the site assessment including sustainable contracting clauses.
- Determine whether the site can be closed because no further action is required.
- Proceed to site classification at Step 4.

Step 3: Initial Testing Program


Step 3
Review findings of historical review from Step 2, and develop scope of work for Phase II ESA, ensuring to consider future impacts of climate change
Conduct a Phase II ESA and develop CSM using sustainable methods to investigate contaminant concentrations and consult stakeholders
Given current or intended federal land use, determine if the site is contaminated based on Treasury Board definition
Yes
No
Proceed to Step 4
No further action needed – close the site on the FCSI and record rationale
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

Identify current or intended federal use for impacted area

Before remediation or risk management (R/RM) strategies are identified and evaluated, the current or intended federal land use of a site must be agreed upon to determine the appropriate standard for remediation. Whether the site is used for industrial, commercial, agricultural or residential/parkland purposes, each will have varying degrees of human health and ecological protection. The levels of protection provided by CCME standards ensure that the remediated land has the potential to support most activities associated with the intended land use.

- **Agricultural:** growing crops, raising livestock, natural areas including National Wildlife Areas and Migratory Bird Sanctuaries*
- **Residential/Parkland:** residential or recreational activities, buffer areas between residences, campgrounds
- **Commercial:**† public access, malls, cultivated lawns, flowerbeds**, gas stations
- **Industrial:**† restricted access, production, manufacturing or construction of goods

*Natural areas consist of natural wild land (including national parks) that would apply the same standards as agricultural land for remediation purposes.

**Cultivated lawns and flowerbeds must be part of the commercial property, and not used as a public area (i.e., picnic or park areas).

†Commercial and industrial land must still be under the responsibility of the federal government.

Under the TB Secretariat Policy on Management of Real Property (TBS, 2006), remediation must be undertaken to the extent required for current or intended federal use. If a custodian plans to divest the property, he/she may remediate beyond federal standards, but the supplementary (above the current or intended federal land use) remediation will not be covered by FCSAP funds.

Treasury Board of Canada (TB) definition of a contaminated site

According to the TB definition, a contaminated site is "one at which substances occur at concentrations (1) above background (normally occurring) levels and pose or are likely to pose an immediate or long-term hazard to human health or the environment, or (2) exceeding levels specified in policies and regulations."

If there are no guidelines available, custodians should base their determination of a contaminated site on the background level, by looking at existing literature or undertaking additional sample analysis. Before moving to the next step, the custodian should be able to confirm whether or not the site is contaminated.

How Fisheries and Oceans Canada (DFO) expert support can assist

- Assist with identification of fish, fish habitat and fish/fisheries information.
- Provide advice on:
    - Characterization of fish habitat or habitat mapping;
    - Confirmation of aquatic species, including species listed under the Species at Risk Act (SARA); and
    - Expectations associated with fish and fish habitat data collection.

- Document review (e.g., Phase II ESA (CSA, 2004) report, conceptual site model [CSM]) with respect to the risk(s) (including receptors, hazard and exposure) to fish and fish habitat.
- Review sampling plan to ensure that data collected will accurately represent the site and assess risks to fish and fish habitat.
- Participate in site visit activities with custodians and other stakeholders to address potential issues and become familiar with the site.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).
- Provide advice on compliance requirements under the *Fisheries Act* and other environmental requirements.

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice on and/or review of the Phase II ESA (CSA, 2004) report, with respect to ecological risks (including receptors, hazard and exposure).
- Provide advice on planning of the Phase III investigation (including providing advice on sampling plan, sampling techniques and technologies, quality assurance/quality control (QA/QC) program, and Conceptual Site Model (CSM).
- Provide advice on CCME Canadian Environmental Quality Guidelines or other applicable guidelines:
    - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)
    - A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
    - A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)
    - A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)
- Participate in site visit activities with custodians and other stakeholders to address potential issues and become familiar with the site.
- Provide advice on the analysis of data.

How Health Canada (HC) expert support can assist

- Provide advice on and/or review of the CSM.
- Provide advice on the characterization of the site and whether there are data gaps associated with site characterization that may impact assessment of human health risks.
- Provide advice and training on sampling techniques and technologies.
- Review sampling plan to ensure that data collected will accurately represent the site and assess human health risks.
- Provide advice on QA/QC programs.
- Provide advice on Canadian Environmental Quality Guidelines or other guidelines that are applicable to screening chemicals for potential human health risks:
    - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)
    - A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
    - A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)

    - A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)
- Participate in site visit activities with custodians and other stakeholders to address potential issues and become familiar with the site.
- Provide advice on the analysis of data from laboratories (adequate detection limits, etc.).
- Provide advice on CCME Canadian Environmental Quality Guidelines (soil, water or sediment) for the protection of human health and Canadian Drinking Water Guidelines (HC, 2014), and/or on the adoption of standards from other jurisdictions.
- Provide advice, guidance and training on the characterization and delineation of contamination at a site in ESA reports so that custodians can better risk-manage sites and obtain adequate data for use in Human Health Risk Assessment (HHRA), including:
    - Advice on and/or review of CSM with respect to human health;
    - Advice on characterization of the site;
    - Advice on the sampling and analysis plan to ensure that data collected will accurately represent the site and supply sufficient data to allow for the assessment of potential human health risks.
- Participate in site visit activities with custodians and other stakeholders to address potential issues and become familiar with the site.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice on, or develop statements of work for the completion of Phase II ESAs (CSA, 2004).
- Assist in determining whether further work is required or no further action is necessary.

How the FCSAP Secretariat can assist

- Provide assistance in using the Priority for Assessment Tool (PAT) (FCSAP, update in progress) and the Eligible Cost Guidance document, 5.0 (FCSAP, update in progress) as required.

Supporting documents and tools specific to Step 3

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report (CCME, 1993)
- Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries (CCME, 1993)
- Subsurface Assessment Handbook for Contaminated Sites (CCME, 1994)
- Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CCME, 2008)
- CCME Canadian Environmental Quality Guidelines:
    - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)

- A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
- A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)
- A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- Phase II ESA SOW incorporating Science-based Expert Support Input (A Federal Approach to Contaminated Sites, Appendix C, CSMWG, 1999)
- Framework for Addressing and Managing Aquatic Contaminated Sites Under the Federal Contaminated Sites Action Plan (FCSAP, 2011)
- FCSAP Guidance Document on Statements of Work for Ecological Risk Assessments (ERAs) at Federal Sites (FCSAP, 2011)
- FCSAP Ecological Risk Assessment Guidance (FCSAP, 2012)
    - Module 1: Toxicity Test Selection and Interpretation (FCSAP, 2010)
    - Module 2: Selection or Development of Site-specific Toxicity Reference Values (FCSAP, 2010)
    - Module 3: Standardization of Wildlife Receptor Characteristics (FCSAP, 2012)
    - Module 4: Causality Assessment: Determining the Causes of Impairment at Contaminated Sites: Are Observed Effects Due to Exposure to Site-Related Chemicals or Due to Other Stressors? (FCSAP, 2013)
    - Module 5: Defining Background Conditions and Using Background Concentrations (FCSAP, 2015)
- Federal Interim Groundwater Guidelines (FCSAP, 2016)
    - Federal Interim Groundwater Guidelines Update (FCSAP, 2016)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)

Other Guidance

- Canadian Standards Association (CSA) Standards for Phase II Environmental Site Assessment (CSA, 2000)
- For Human Health Risk Assessment (HHRA): Federal Contaminated Site Risk Assessment in Canada available on request from cs-sc@hc-sc.gc.ca,:
    - Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0 (HC, 2012)
    - Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0 (HC, 2010)
    - Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0 (HC, 2010)
    - Part V Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) (HC, 2010)
    - Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment ($DQRA_{RAD}$) (HC, 2010)
    - Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites (HC, 2010)

- Supplemental Guidance on Developing a Contract Statement of Work for Human Health Preliminary Quantitative Risk Assessment (PQRA) and Detailed Quantitative Risk Assessment (DQRA) (HC, 2010)
- Guidance and Orientation for the Selection of Technologies (GOST) (PSPC/NRC, 2012)
- Guidelines for Canadian Drinking Water Quality (HC, 2014)

Step 4: Classify Site (optional)

Step 4 is an optional step that can be used at the discretion of the custodians who wish to complete a preliminary assessment of a site's classification or if they wish to determine if enough information on the site has already been gathered to complete a robust site classification. Equally, custodians can choose to proceed directly from Step 3 to Step 5 if they need to collect more data to complete a meaningful classification (at Step 6).

In Step 4, custodians complete the Canadian Council of Ministers of the Environment's (CCME) National Classification System for Contaminated Sites Guidance Document (NCSCS) (CCME, 2008) or the Federal Contaminated Sites Action Plan (FCSAP) Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015). Custodians should refer to the Supplemental Guidance for the Scoring of Sites Using the National Classification System for Contaminated Sites (NCSCS) and Aquatic Sites Classification Systems (ASCS) under the Federal Contaminated Sites Action Plan (FCSAP, 2013). This exercise can further help the custodians identify the priority of sites for subsequent action (assessment or remediation).

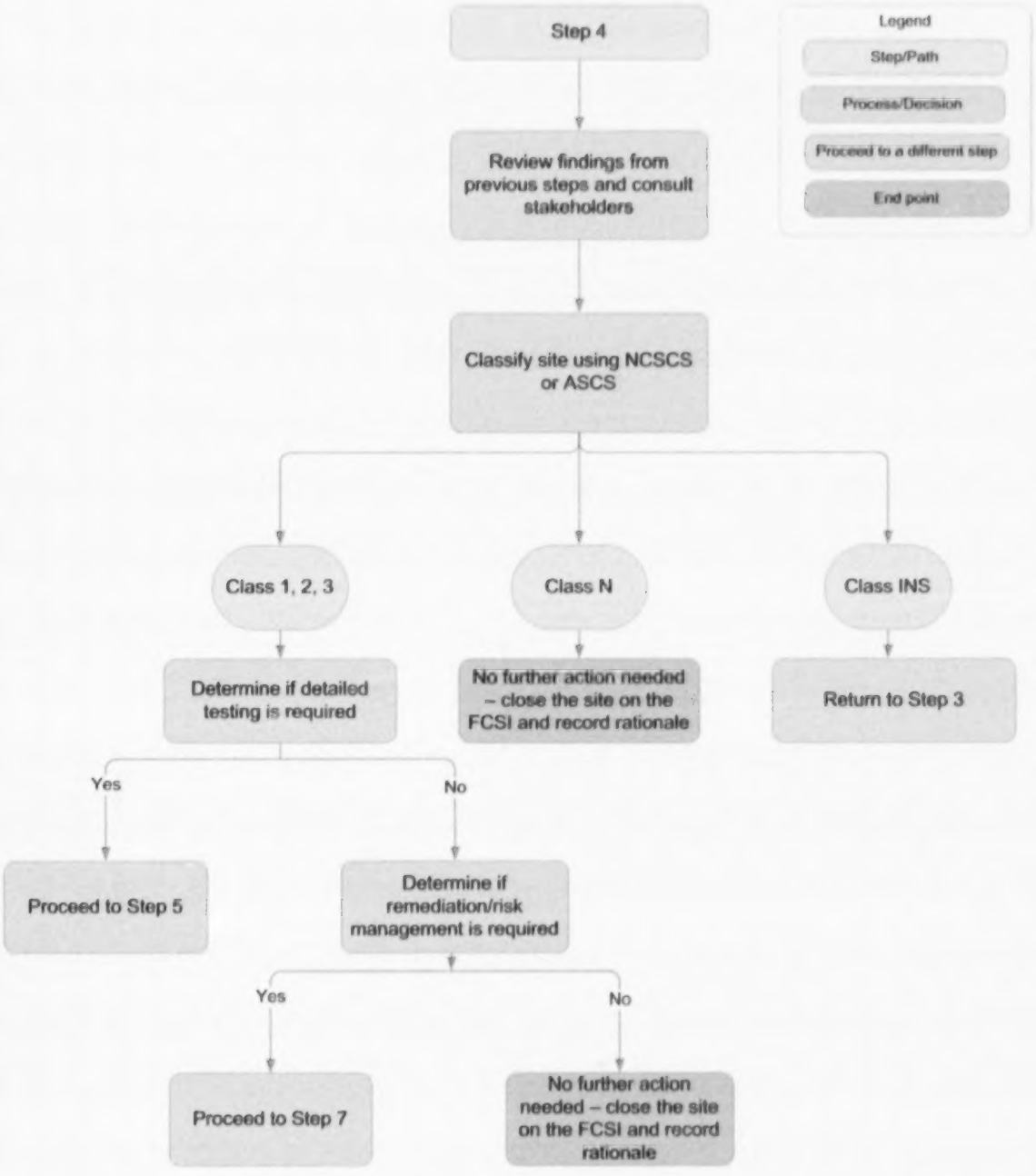
Site classifications include Class 1, 2, 3, INS (insufficient information) or N (not a priority for action), with Class 1 having the highest priority for action. For Phase II of FCSAP program (2011–2016), only Class 1 sites and ongoing Class 2 sites (with FCSAP remediation expenditures prior to April 1, 2011) are eligible for FCSAP remediation funding.

When further testing is not required and sufficient site information is available, and if the custodian wishes to have the site considered for FCSAP remediation/risk management (R/RM) funding, the site classification worksheet can be reviewed by the expert support departments and the FCSAP Secretariat to determine if the site meets the eligibility requirements for FCSAP remediation/risk management funding. However, it should be noted that classification of sites conducted at Step 4 are generally too preliminary to be reviewed for FCSAP funding eligibility. Very often it is necessary to complete Steps 5 and 6 to obtain a site eligibility review. Step 4 remains more of an internal exercise for custodians.

Key decision(s):

- Determine if the completion of a preliminary assessment of a site's classification is needed in this step.
- Determine if it is preferable to collect more information before assessing a site's classification – do not complete Step 4 and go right to Step 5 (Detailed Testing Program).
- Alternatively, determine the classification of the site at this step.
- Based on the level of priority for action and on the completeness of the classification assessment, determine if the site is eligible to request FCSAP R/RM funding and proceed to Step 7 (Develop Remediation/ Risk Management Strategy).

Step 4: Classify Site (Optional)


Step 4
Review findings from previous steps and consult stakeholders
Classify site using NCSCS or ASCS
Class 1, 2, 3
Class N
Class INS
Determine if detailed testing is required
No further action needed – close the site on the FCSI and record rationale
Return to Step 3
Yes
No
Proceed to Step 5
Determine if remediation/risk management is required
Yes
No
Proceed to Step 7
No further action needed – close the site on the FCSI and record rationale
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Review and provide advice on relevant (i.e., fish and fish habitat) components of the National Classification System for Contaminated Sites (NCSCS) (CCME, 2008) or Federal Contaminated Sites Action Plan (FCSAP) Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015).
- Provide access to training and resources for the ASCS [such as the FCSAP Aquatic Sites Classification System Detailed User Guidance Manual (FCSAP, 2015)].
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice on the use and interpretation of NCSCS spreadsheet (CCME, 2008) and ASCS worksheets (FCSAP, 2014).
- Review and provide advice on ecological concerns described by the NCSCS or the ASCS.
- Provide training and guidance on the use of NCSCS or ASCS worksheets.

How Health Canada (HC) expert support can assist

- Review and provide advice on relevant (i.e., human health) components of NCSCS and ASCS classification scores and associated background information, including interpretation of NCSCS and ASCS worksheets.
- Provide advice, guidance, training and/or peer review on conducting Human Health Risk Assessments (HHRA) and interpreting their results with respect to site classification.
- Provide advice and support in ranking and prioritizing sites from a human health risk perspective.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice throughout Step 4, including on determining whether R/RM is required at a site.
- Assist in determining whether further work is required or whether no further action is necessary.

How the FCSAP Secretariat can assist

- Provide assistance in using the Priority for Assessment Tool (PAT) (FCSAP, update in progress) and the Eligible Cost Guidance, v. 5.0 document (FCASP, update in progress), as required.
- Provide support to custodians on the process for submitting a site to the FCSAP Priority List for remediation funding (navigating through the Interdepartmental Data Exchange Application [IDEA], mandatory documents, reports and other eligibility concerns) if sufficient information about the condition of the site is available at this step.

Supporting documents and tools specific to Step 4

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- National Classification System for Contaminated Sites (NCSCS) Guidance Document (CCME, 2008)
- National Classification System for Contaminated Sites Spreadsheet (CCME, 2008)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- Eligible Costs Guidance, 5.0 (FCSAP, update in progress)
- Supplemental Guidance for the Scoring of Sites Using the National Classification System for Contaminated Sites (NCSCS) and Aquatic Sites Classification System (ASCS) under the Federal Contaminated Sites Action Plan (FCSAP, 2013)
- Aquatic Site Classification System (ASCS) - Version 3.2 Detailed User Guidance Manual (FCSAP, 2015)
- Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)

Step 5: Detailed Testing Program

If the results of the Initial Testing Program (Step 3) indicate that contaminant levels exceed guidelines or background levels and may pose a risk, a detailed testing program may be required in order to address outstanding issues.

Step 5 involves investigating site conditions, characterizing the impacted media and further delineating the areas of concern identified during Step 3. The Detailed Testing Program is accomplished by developing and completing a Phase III Environmental Site Assessment (ESA), updating and finalising the Conceptual Site Model (CSM) from the Initial Testing (Step 3), and continuing consultations with stakeholders. Sustainable site assessment methods should be implemented. Furthermore, for each of these activities, future climate change considerations should be observed.

The type and scope of the detailed assessment to be conducted at Step 5 depend on the site conditions and should aim to allow a determination if further management action is required, and aim to allow a robust classification of the site as per CCME National Classification System Detailed Evaluation Form (in Step 6).

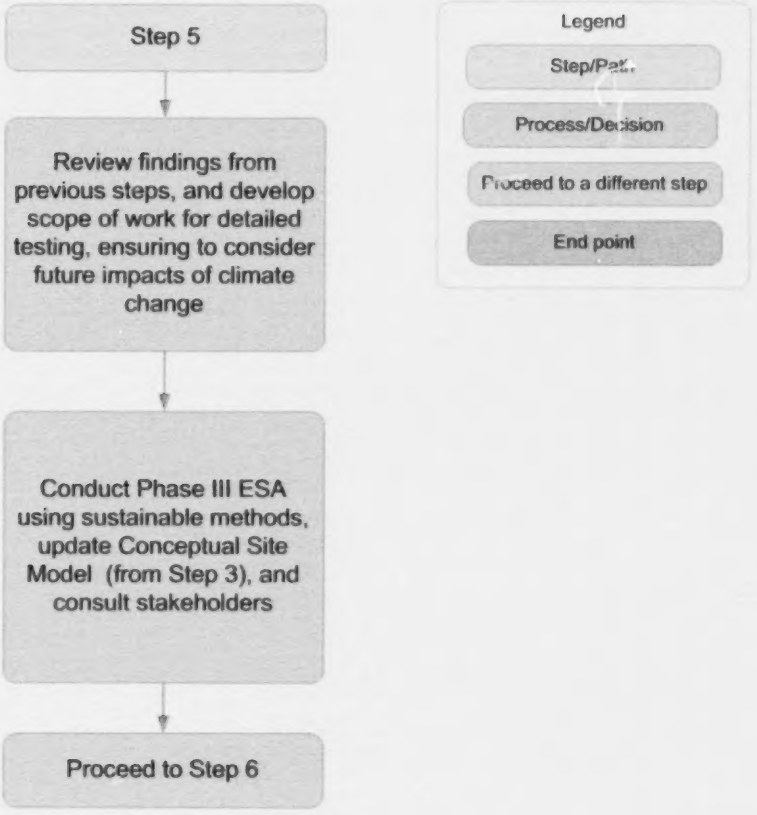
Generally, the detailed testing program will concentrate on areas identified in the initial testing program and involve a similar systematic process of sampling and analysis, evaluation, conclusions and recommendations; however, a greater number of samples are usually collected and a smaller suite of chemical substances may be analyzed as the program converges on the environmental issues and the full extent of the contamination.

Custodian who have not conducted the optional preliminarily classification of their site(s) at Step 4 may once again use the Priority for Assessment Tool (PAT) (FCSAP, update in progress) or an equivalent system to prioritise their site(s) at this step.

Key decision(s):

- Determine the need for revising existing detailed site assessment in order to ensure sufficient information has been gathered to classify site in Step 6.
- Determined the need to further substantiate the existing initial site assessment (Step 3) in order to ensure sufficient information has been gathered in Step 6.
- Conduct a more detailed assessment of the effects of climate change at the site based on the preliminary assessment in Step 3.
- Determine pathways for integrating sustainable site assessment practices into the site assessment that target reducing energy use and minimizing waste production.

Step 5: Detailed Testing Program


Step 5
Review findings from previous steps, and develop scope of work for detailed testing, ensuring to consider future impacts of climate change
Conduct Phase III ESA using sustainable methods, update Conceptual Site Model (from Step 3), and consult stakeholders
Proceed to Step 6
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Assist with determining level of impact to fish and fish habitat (e.g., contaminants-related impacts to fish habitat).
- Provide advice on physical processes (e.g., erosion/deposition, susceptibility to tides/currents/floods) that could affect fish and fish habitat.
- Review documents (e.g., draft site assessment) with respect to fish and fish habitat.
- Provide advice to custodians on the development of terms of reference for contracts to prevent or mitigate potential impacts to fish and fish habitat associated with testing.
- Review sampling plan to ensure that data collected will accurately represent the site and assess risks to fish and fish habitat.
- Participate in site visit activities.
- Assist with the identification of aquatic receptors and pathways to focus on during the assessment.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).
- Provide advice on compliance requirements under the *Fisheries Act* and other environmental requirements.

How Environment and Climate Change Canada (ECCC) expert support can assist

- Review environmental site assessment (ESA) reports and provide advice on treatment of data.
- Review sampling plan to ensure that data collected will accurately represent the site and assess ecological risks.
- Provide advice on sampling and analytical techniques and technologies.
- Provide advice on data requirements of an Ecological Risk Assessment (ERA) and future monitoring plans.
- Provide advice on quality assurance/quality control (QA/QC) programs.
- Provide advice on applicable environmental quality guidelines.
- Participate in site visit activities.
- Provide advice on developing a site management strategy.
- Provide advice on compliance requirements under the *Fisheries Act* and other environmental requirements.

How Health Canada (HC) expert support can assist

- Review ESA reports and CSM.
- Review sampling plan to ensure that data collected will accurately represent the site and provide input for the assessment of potential human health risks.
- Provide advice on sampling techniques and technologies.
- Provide advice on data requirements of a Human Health Risk Assessment (HHRA) and future monitoring plans.
- Provide advice on QA/QC programs.
- Provide advice on applicable environmental quality guidelines.
- Participate in site visit activities.
- Provide advice on developing a site management strategy.
- Provide advice on the treatment of data.

- Review ESA reports, and where applicable, PQRA, and provide detailed technical comments regarding the data requirements necessary to adequately characterize contamination at the site.
- Review the sampling and analysis plan to ensure that data collected will be useful in delineating contamination at the site and that the data will be adequate to support the assessment of human health risks.
- Provide advice on the development of terms of reference for contracts for HHRA.
- Provide advice on the selection and/or development of human-health-based remediation criteria and/or risk management.
- Provide advice, guidance and training on the characterization and delineation of contamination at a site so that custodians can adequately characterize their site for the purpose of risk management.
- Provide advice, guidance and training on HHRA so that custodians can obtain adequate data for use in site management with the goal of risk reduction.
- Participate in site visit activities.
- Assist with developing a CSM that includes the identification of human receptors and pathways, and that allows more targeted site investigation, which will allow for proper characterization of the contamination as it applies to human exposure.
- Provide advice on applicable human-health-based guidelines and standards and/or recommended interim values where guidelines and standards area not available (e.g., perfluorooctane sulfonate [PFOS]).

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice throughout Step 5—including on the development of a statement of work (SOW), completion of the Phase III and preliminary liabilities estimates and the use of project management tools such as preliminary project planning and the project charter.
- Provide advice to custodians in the development of terms of reference for contracts.
- Assist in determining whether further work is required or no further action is necessary.

How the FCSAP Secretariat can assist

- Provide assistance in using the Priority for Assessment Tool (FCSAP, update in progress) and the Eligible Cost Guidance, v. 5.0 document (FCSAP, update in progress) as required.

Supporting documents and tools specific to Step 5

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report (CCME, 1993)
- Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries (CCME, 1993)
- Subsurface Assessment Handbook for Contaminated Sites (CCME, 1994)
- Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CCME, 2001)

- CCME Canadian Environmental Quality Guidelines:
  - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)
  - A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
  - A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)
  - A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- FCSAP Ecological Risk Assessment Guidance (FCSAP, 2012)
  - Module 1: Toxicity Test Selection and Interpretation (FCSAP, 2010)
  - Module 2: Selection or Development of Site-specific Toxicity Reference Values (FCSAP, 2010)
  - Module 3: Standardization of Wildlife Receptor Characteristics (FCSAP, 2012)
  - Module 4: Causality Assessment: Determining the Causes of Impairment at Contaminated Sites: Are Observed Effects Due to Exposure to Site-Related Chemicals or Due to Other Stressors? (FCSAP, 2013)
  - Module 5: Defining Background Conditions and Using Background Concentrations (FCSAP, 2015)
- FCSAP Guidance Document on Statements of Work for Ecological Risk Assessments (ERAs) at Federal Sites (FCSAP, 2011)
- Federal Interim Groundwater Guidelines (FCSAP, 2016)
  - Federal Interim Groundwater Guidelines Update (FCSAP, 2016)
- Priority for Assessment Tool (PAT) (FCSAP, update in progress)

Other Guidance

- Canadian Standards Association (CSA) Standards for Phase II Environmental Site Assessments (CSA, 2000)
- Canada–Ontario Decision-Making Framework (DMF) for Assessment of Great Lakes Contaminated Sediment (ECCC and MOE, 2008)
- For Human Health Risk Assessment (HHRA): Federal Contaminated Site Risk Assessment in Canada:
  - Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0 (HC, 2012) available on request from cs-sc@hc-sc.gc.ca,
  - Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0 (HC, 2010) available on request from cs-sc@hc-sc.gc.ca,
  - Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0 (HC, 2010)
  - Part V Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) (HC, 2010)
  - Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment ($DQRA_{RAD}$) (HC, 2010)
  - Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites (HC, 2010)

- Supplemental Guidance on Developing a Contract Statement of Work (SOW) for Human Health Preliminary Quantitative Risk Assessment (PQRA) and Detailed Quantitative Risk Assessment (DQRA) (HC, 2010)
- Supplemental Guidance on Human Health Risk Assessment for Country Foods ($HHRA_{Foods}$) (HC, 2010)
- Guidelines for Canadian Drinking Water Quality (HC, 2014)

Step 6: Re-Classify Site

At this step, the site is classified for the first time, or reclassified from Step 4 if new information acquired through the Detailed Testing Program (Step 5) must be input into the classification system in order to accurately assess the priority for action of a site. A complete site classification is required in order to receive FCSAP remediation/risk management funding. Custodians should complete the Canadian Council of Ministers of the Environment (CCME) National Classification System for Contaminated Sites spreadsheets (NCSCS) (CCME, 2008) or the Federal Contaminated Sites Action Plan Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015) based on the results of the initial and detailed testing programs as detailed in the National Classification System for Contaminated Sites Guidance Document (CCME, 2008). Stakeholders can provide key information about the site history and condition, end use of the site, exposure pathways, receptors, contaminants of potential concern, and safe exposure limits.

Site classifications include Class 1, 2, 3, INS (insufficient information) or N (not a priority for action), with Class 1 having the highest priority for action. For Phase II of FCSAP (2011/12-2015/2016), only Class 1 sites and ongoing Class 2 sites (with FCSAP remediation expenditures prior to April 1, 2011) are eligible for FCSAP funding.

At this step, custodians should consider whether there is sufficient information to meet the five mandatory recognition criteria for reporting a liability as defined by the Treasury Board Secretariat of Canada and, if so, report the liability for the site using the FCSI portal. The estimate of a remediation liability includes costs directly attributable to remediation activities required to bring the site up to the current minimum standard for use prior to contamination.

A liability for remediation of contaminated sites should be recognized when, as of the financial reporting date, the following apply:

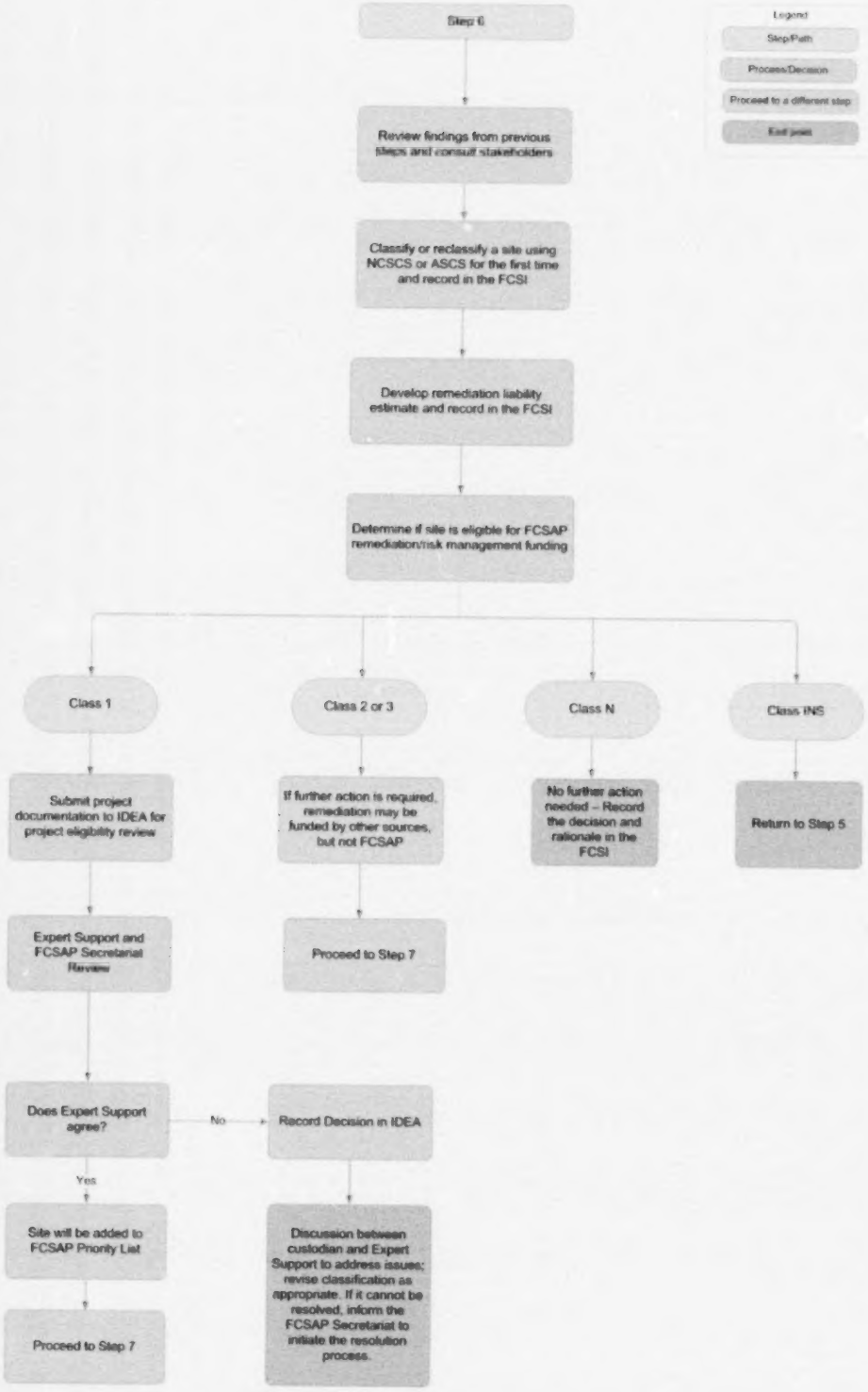
- An environmental standard exists;
- Contamination exceeds the environmental standard;
- The Government of Canada:
  - owns the land; or
  - is directly responsible; or
  - accepts responsibility (e.g., when there is little, if any, discretion to avoid the obligation);
- It is expected that future economic benefits will be given up;
- A reasonable estimate of the amount can be made.

After completion of Step 6, if the custodian wishes to have the site considered for FCSAP remediation/risk management (R/RM) funding, the classification worksheets will be reviewed by expert support departments to determine if the site meets the eligibility requirements for FCSAP R/RM funding. Only Class 1, 2 and 3 sites may eventually proceed to Step 7, although Class 1 and Class 2/3 sites require different follow up actions.

Key decision(s) for Step 6:

- Determine the new/revised site classification and if further action is required.
- If further action is required, determine if site is eligible for FCSAP R/RM funding and proceed to Step 7.

Step 6: Re-Classify Site


Step 6
Review findings from previous steps and consult stakeholders
Classify or reclassify a site using NCSCS or ASCS for the first time and record in the FCSI
Develop remediation liability estimate and record in the FCSI
Determine if site is eligible for FCSAP remediation/risk management funding
Class 1
Class 2 or 3
Class N
Class INS
Submit project documentation to IDEA for project eligibility review
If further action is required, remediation may be funded by other sources, but not FCSAP
No further action needed – Record the decision and rationale in the FCSI
Return to Step 5
Expert Support and FCSAP Secretariat Review
Proceed to Step 7
Does Expert Support agree?
No
Record Decision in IDEA
Yes
Site will be added to FCSAP Priority List
Discussion between custodian and Expert Support to address issues; revise classification as appropriate. If it cannot be resolved, inform the FCSAP Secretariat to initiate the resolution process.
Proceed to Step 7
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

Treasury Board of Canada (TB) definition

According to the TB definition, a contaminated site is "one at which substances occur at concentrations (1) above background (normally occurring) levels and pose or are likely to pose an immediate or long-term hazard to human health or the environment, or (2) exceeding levels specified in policies and regulations".

Consider seeking FCSAP R/RM funding

For federal contaminated sites to be eligible for R/RM funding under the FCSAP Phase II (2011–2012 to 2015–2016), the following conditions must be met:

- The site must meet the TB definition of a contaminated site.
- Contamination must have occurred before April 1, 1998.
- For Phase II of the FCSAP Program (2011/12-2015/16) the site must be classified as Class 1 using an appropriate site classification system identified in the FCSAP Guidance Manual. Class 2 sites are also eligible under FCSAP if remediation expenditures were incurred prior to April 1, 2011.
- The site must have an associated financial liability reported in the Public Accounts of Canada, in accordance with current TB guidance on recording remediation liabilities for contaminated sites.
    - In those circumstances where FCSAP funding is used for remediation expenditures but no liability can be recorded, custodians should provide a justification as part of the FCSAP Secretariat's review of priority sites.
    - An example is when a site with no opening liability for the fiscal year receives assessment and remediation funding in one field season.
- A complete and accurate site record, including annual expenditure and liability data, must be recorded in the Treasury Board of Canada Secretariat (TBS) Federal Contaminated Sites Inventory (FCSI), in compliance with Treasury Board's Policy on Management of Real Property and the Reporting Standard on Real Property.

Custodians seeking or having obtained FCSAP funding must use the Interdepartmental Data Exchange Application (IDEA). IDEA was developed under FCSAP to facilitate the exchange of information between the program Secretariat, custodians of federal contaminated sites (departments, agencies, and consolidated Crown corporations), and the Expert Support departments (Health (HC), Environment (ECCC), Fisheries and Oceans (DFO), and Public Works (PSPC)). On IDEA, custodians submit new site funding requests and update their previously approved site submissions. Custodians who need to create user accounts should contact the FCSAP Secretariat.

How Fisheries and Oceans Canada (DFO) expert support can assist

- Review relevant components (e.g., fish and fish habitat) of the National Contaminated Sites Classification System (NCSCS) Guidance Document (CCME, 2008) or Aquatic Sites Classification System (ASCS) classification scores and associated reports (FCSAP, 2015).
- Provide training resources (such as the FCSAP Aquatic Sites Classification System (FCSAP, 2015). Detailed User Guidance Manual) and provide advice on the submission score.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).

How Environment and Climate Change Canada (ECCC) expert support can assist

- Review the NCSCS or ASCS score and associated reports to confirm the accuracy of the classification derived by the custodian (mandatory for sites that custodians are requesting be added to the FCSAP Priority List for R/RM funding).
- Provide information on training resources.

How Health Canada (HC) expert support can assist

- Review human health components of the NCSCS and ASCS and associated reports to confirm the accuracy of the classification derived by the custodian.
- Provide advice on the use and interpretation of NCSCS and ASCS worksheets.
- Provide advice, guidance, training and/or peer review on conducting and interpreting Human Health Risk Assessment (HHRA) results as they apply to site classification.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice on the review and classification, and liaise with other expert support departments.

How the FCSAP Secretariat can assist

- Provide clarification on the application of the Eligible Cost Guidance, v. 5.0 document (FCSAP, 2016), and the National Contaminated Sites Classification System (NCSCS) Guidance Document (CCME, 2008) and Aquatic Sites Classification System (FCSAP, 2015) as required.
- Communicate decision to custodians on the eligibility of new sites once reviewed, and add new eligible sites to the FCSAP Priority Site List.
- Provide information on how to access and use the Interdepartmental Data Exchange Application (IDEA).

Supporting documents and tools specific to Step 6

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- CCME National Classification System for Contaminated Sites (NCSCS) Guidance Document (CCME, 2008)
- National Classification System for Contaminated Sites Spreadsheet (CCME, 2008)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- Supplemental Guidance for the Scoring of Sites Using the National Classification System for Contaminated Sites (NCSCS) and Aquatic Sites Classification Systems (ASCS) under the Federal Contaminated Sites Action Plan (FCSAP, 2013)
- Aquatic Site Classification System (ASCS) - Version 3.2 Detailed User Guidance Manual (FCSAP, 2015)

- Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015)

Other Guidance and Tools

- Checklist for Peer Review of Detailed Human Health Risk Assessment (HHRA) (HC, 2010)
- Remediation Liabilities Related to Contaminated Sites: A Supplement to the Financial Information Strategy (FIS) Manual (TBS, 2010)
- Interdepartmental Data Exchange Application (IDEA)

Step 7: Develop Remediation/Risk Management (R/RM) Strategy

A remediation/risk management (R/RM) strategy is developed once the results of the preliminary (Step 3) and detailed (Step 5) testing have indicated that risks from contamination must be addressed. For the site to be funded under the Federal Contaminated Sites Action Plan (FCSAP) for R/RM activities, the site also needs to be classified as either Class 1 or ongoing Class 2 (applicable to Phase II of the FCSAP program (2011/12 – 2015/16)) meaning high or medium priority for action, respectively.

Selection of the R/RM strategy is one of the most critical decisions in the 10-step process, since the outcome will largely determine the cost and effectiveness of the chosen approach on the reduction of risk to human health and the environment, and on the reduction of financial liability. The financial liability for the site, based on the risk and the federal government's obligation to address it, should also be calculated by the end of Step 7.

Careful consideration and evaluation of R/RM objectives, options and regulatory requirements will reduce the possibility of error and substantially increase the affordability and technical effectiveness of the proposed site management strategy. When selecting R/RM methods, consider sustainability (see Appendix A) and climate change measures. Look for opportunities to demonstrate the feasibility of incorporating sustainable remediation activities. The Preliminary Sustainability Plan (PSP) developed in Step 2 should be updated based on the site management strategy and the expected activities to occur on site during R/RM implementation and execution.

When selecting sustainable R/RM methods, consider risk management (as opposed to remediation) approaches where appropriate land-use restrictions and human health and environmental protection can be assured. Where risk management approaches are not possible, consider the use of in-situ remediation techniques and those that destroy contaminants. Use a qualitative, semi-qualitative [i.e., the Sustainable Development Tool (SDT) (PSPC, 2016), or quantitative (i.e., life-cycle analysis) approach to evaluate the sustainability of viable R/RM options for the site. For general activities that should be considered in the sustainability plan, see Appendix A.

At Step 7, it is recommended that custodians begin to fill in the Guidance for Site Closure Tool for Federal Contaminated Sites (SCT) (FCSAP, 2012). It enables custodians to evaluate key decisions and document important information about the R/RM activities leading to the eventual closure or long-term monitoring/management (LTM) of the site.

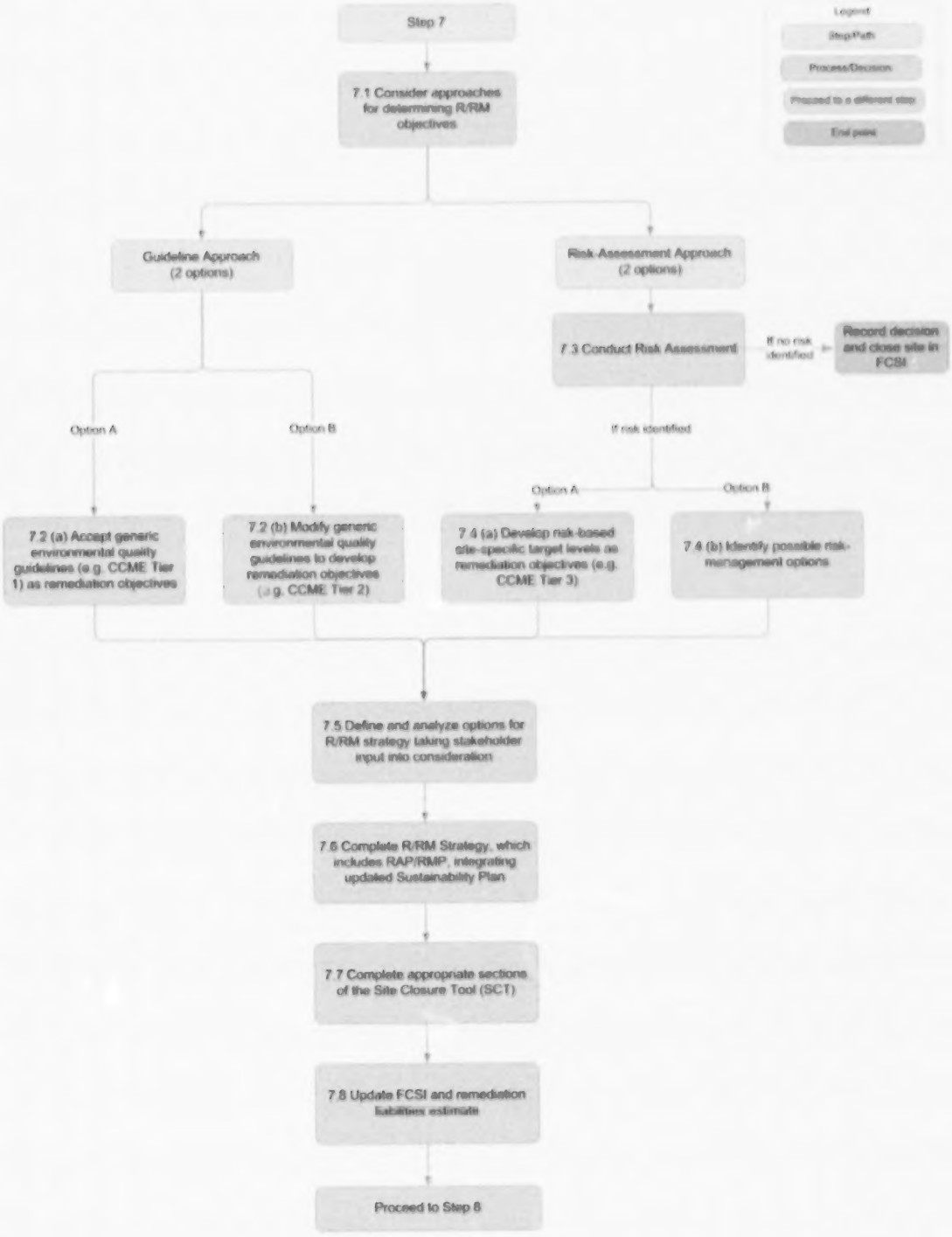
Step 7 describes two approaches, the Guideline Approach and the Risk Assessment Approach. A description of each of Step 7's sub activities follows the flow diagram.

Key decision(s):

- Determine whether a guideline approach, generic or modified, or a risk assessment approach to establish R/RM objectives will be applied.
- Establish corresponding R/RM objectives.
- Determine which R/RM options should be considered, and choose the most appropriate selection.
- Consider climate change effects that may lead to changes in the affected media and future exposure scenarios and receptors when developing the R/RM strategy.
- Consider and integrate feasible sustainability measures into the R/RM strategy.

Step 7: Develop Remediation/Risk Management (R/RM) Strategy

All activities in Step 7 should consider the future impacts of climate change on the site and should aim to use sustainable approaches.


Step 7
7.1 Consider approaches for determining R/RM objectives
Legend
Step/Path
Process/Decision
Proceed to a different step
End point
Guideline Approach (2 options)
Risk Assessment Approach (2 options)
7.3 Conduct Risk Assessment
If no risk identified
Record decision and close site in FCSI
Option A
Option B
If risk identified
Option A
Option B
7.2 (a) Accept generic environmental quality guidelines (e.g. CCME Tier 1) as remediation objectives
7.2 (b) Modify generic environmental quality guidelines to develop remediation objectives (e.g. CCME Tier 2)
7.4 (a) Develop risk-based site-specific target levels as remediation objectives (e.g. CCME Tier 3)
7.4 (b) Identify possible risk-management options
7.5 Define and analyze options for R/RM strategy taking stakeholder input into consideration
7.6 Complete R/RM Strategy, which includes RAP/RMP, integrating updated Sustainability Plan
7.7 Complete appropriate sections of the Site Closure Tool (SCT)
7.8 Update FCSI and remediation liabilities estimate
Proceed to Step 8

Step 7.1: Based on the current and intended land use, consider approaches for developing a site management strategy

To develop their site management strategy, custodians will need to identify the R/RM objectives and select the best options for attaining them. These two important decisions will be made in parallel, based on the current or intended federal use of the site, which was first identified at Step 3 and Step 5 but should be reconfirmed.

R/RM objectives may be developed for a site using a **guideline approach**—where generic or modified guidelines are adopted—or using a **risk assessment approach** to derive site-specific target levels as remediation objectives. Choosing between the guidelines or risk assessment approach depends on the circumstance. For instance, if the potential site management strategies based on the guideline approach are too costly or are unacceptable for other reasons (e.g., technical feasibility or unacceptable environmental damage caused by the remedy); it may be advantageous to perform a risk assessment. A risk assessment may help custodians to better understand and focus on the main drivers of risk at the site, which can optimize R/RM actions. There are many conditions under which one or both of these approaches may be implemented. Switching between the risk assessment and guideline approach is not prohibited; an iterative analysis of the alternatives is encouraged and works to optimize the final strategy. For both approaches, custodians should take into account the effects of future climate changes on their current site conditions – including media, pathways and receptors.

Step 7.2a: Guideline Approach Option A

Accept generic environmental quality guidelines as remediation objectives

Published guidelines such as the CCME Canadian Environmental Quality Guidelines are selected as the remediation objectives. These are conservative, generic numeric concentrations of residual contamination that are considered to be acceptable for a wide range of site conditions and receptors under defined land uses.

Step 7.2b: Guideline Approach Option B

Modify generic environmental quality guidelines to develop remediation objectives

When site conditions, land use, receptors or exposure pathways differ slightly from those set out for the generic guidelines—and when adjustment of certain parameters in equations or pathway exposure assumptions is deemed acceptable based on jurisdictional approval and guidance—it is possible to apply limited modification of generic guidelines.

Step 7.3: Risk Assessment Approach

Conduct risk assessment

When the environmental quality guideline approaches cannot be implemented, or if site conditions are unique or particularly sensitive and would limit the effectiveness of generic criteria, a risk assessment approach may be used to determine if the existing contamination/site conditions represent a risk. If generic environmental quality guidelines for the contaminant of concern do not exist in Canada or other jurisdictions, if costs of remediating to guideline levels

are too high, if the site is particularly large and complex, if the environmental impacts of using available remediation techniques are unacceptable, or if little information is known about the contaminants of concern, risk assessment may be warranted.

Depending on the site and receptors present, both a human health and an ecological risk assessment will likely be necessary. Guidance for these assessments is published by the FCSAP program, the Canadian Council of Ministers of the Environment (CCME), Health Canada (HC) and Environment and Climate Change Canada (ECCC). A risk assessment at Step 7 typically requires substantially more effort and detail than simpler risk assessments that may have been completed previously.

A risk assessment can identify R/RM Site Specific Target Levels, but can also reveal that no unacceptable risk exists at this site. When this is the case then no other, no further action is required and the site should be closed in the Federal Contaminated Sites Inventory (FCSI) (Treasury Board Secretariat). No further action should also be recorded in the Site Closure Tool (mandatory for FCSAP-funded sites) (FCSAP, 2012) and the recommended Tool for Risk Assessment Validation (TRAV) (found in the Site Closure Tool). If risks are identified, they can either be managed through remediation to site-specific target levels or by risk management of the contamination in such a way that no risk exists, essentially blocking exposure pathways between the contamination and the receptors of concern.

Step 7.4a: Risk-Assessment Approach Option A

Develop risk-based site-specific target levels as remediation objectives

Site-specific target levels (SSTLs) are established using risk assessment. SSTLs are concentrations at or below which no risk exists for this particular site. Remediation should aim to attain those levels.

Step 7.4b: Risk-Assessment Approach Option B

Identify possible risk management options

Options for risk management typically involve engineering or institutional controls that a) interrupt the exposure pathways (e.g., installing fencing, filtering drinking water, removing children's sandboxes, importing clean soil for raised garden beds); b) remove receptors (e.g., not allowing deep-rooted trees on site); or c) change the form of the contaminant to make it less accessible (e.g., liming soil to reduce metal mobilization, encapsulating metals in cement).

Step 7.5: Define and analyze options for site management strategy, taking stakeholders' input into consideration

A site management strategy may include one or a combination of R/RM options to address a variety of site conditions. For example, it may be decided that remediation methods are appropriate for some areas of the site or impacted media, but that other site conditions are more appropriately addressed by engineering and/or institutional controls to prevent potential exposure by receptors. In this context, it is necessary to consider various options and to assess their relative advantages and disadvantages. See Appendix B for further guidance on how to assess available options. Custodians should consider future effects of climate change and apply sustainability principles when selecting R/RM methods, and look for opportunities to

demonstrate the feasibility of incorporating sustainable remediation methods.

Step 7.6: Select site management strategy and develop remediation action plan/risk management plan (RAP/RMP)

Once the preferred R/RM techniques are determined, a strategy is developed that may rely on a combination of R/RM approaches. One of the main components of the strategy is the Remedial Action Plan (RAP) and/or Risk Management Plan (RMP), depending on the chosen route. Each plan should contain some key details about the site, including the following:

- A summary of all data from previous investigations, including identifying contaminants of concern, affected media and quantity of materials to be treated;
- A summary of the R/RM techniques that were evaluated and how the preferred strategy was chosen;
- A detailed plan for the R/RM processes to be used, as well as an implementation plan and control measures to minimize further risk;
- Updated Preliminary Sustainability Plan (PSP);
- A description of remedial verification and long-term monitoring (LTM) plans.

Step 7.7: Complete appropriate sections of the Site Closure Tool (SCT), including the Tool for Risk Assessment Validation (TRAV)

The Site Closure Tool (SCT) (FCSAP, 2012) is meant to provide custodians with consistent evaluation criteria for determining when it is appropriate to close sites remediated using FCSAP funding. It also provides a template for determining which critical information about site remediation decisions should be documented and summarized in a closure report. The TRAV is embedded within the SCT and acts as a quality assurance tool describing the expectations of ECCC, Fisheries and Oceans Canada (DFO), and HC with respect to the proper procedure for conducting risk assessments. The TRAV is not a mandatory tool, but is strongly recommended by the FCSAP Secretariat. Custodians will begin to fill out the sections of the SCT related to R/RM planning and the quality of site assessment data during Step 7. This will ensure that any deficiencies are identified early enough in the R/RM process that they can be corrected, rather than doing so at the end of the site work.

Step 7.8: Update Federal Contaminated Sites Inventory (FCSI)

The FCSI should be updated to include liability estimates, if the Treasury Board of Canada Secretariat (TBS) liability recognition criteria are met. At this step, custodians should have sufficient information about the site to meet the five mandatory recognition criteria for reporting a liability as defined by the Treasury Board Secretariat of Canada and report the liability for the site using the Federal Contaminated Sites Inventory (FCSI) portal (TBS, 2016). The estimate of a remediation liability includes costs directly attributable to remediation activities required to bring the site up to the current minimum standard for use prior to contamination. See Step 6 for more details.

How Fisheries and Oceans Canada (DFO) expert support can assist

- Provide input and advice on risk management options (including remediation and mitigation measures).

- Review and provide advice on the following points to ensure that activities on site are compliant with DFO's regulatory requirements and mandate to protect fish and fish habitat that support fisheries:
    - draft RAP or RMP;
    - remedial strategy to ensure coherence with broader DFO initiatives;
    - *Species at Risk* Act (SARA) recovery strategies, action plans and management plans to ensure compliance with the SARA-listed aquatic species or particular harvested aquatic species;
    - draft Environmental Assessment (EA) and supporting documentation;
    - draft Ecological Risk Assessment (ERA);
    - plans for physical works and undertakings;
    - mitigation, monitoring and contingency plans.
- Participate in site visit activities (if specific issues arose).
- Identify appropriate contacts within DFO.
- Provide support to the public engagement process.
- Provide advice to custodians on the development of terms of reference for contracts to prevent or mitigate potential impacts to fish and fish habitat that would be associated with testing or R/RM programs.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).
- Provide advice on compliance requirements under the *Fisheries Act* and other environmental requirements.

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice on and/or review of ERAs, remediation objectives, risk-based site-specific target levels, RAPS or RMPs.
- Provide advice on the accuracy of model assumptions made during the ERA and the Risk Management Strategy (RMS).
- Provide advice so custodians may ensure that R/RM activities on site are compliant with regulatory requirements including the *Fisheries Act* and other environmental requirements.
- Provide advice on the development and comparison of R/RM options.
- Provide advice to custodians in the development of terms of reference for contracts.
- Provide advice on mitigation activities and sustainable strategies to reduce impacts from remediation.
- Assist on the EA for remediation activities (e.g., excavation) where required under the Canadian Environmental Assessment Act, 2012 (CEAA 2012) (Note: sending the EA to the FCSAP expert support department does not replace the formal EA process).
- Participate in site visit activities.

How Health Canada (HC) expert support can assist

- Provide advice, guidance, training and review on developing site-specific human health remediation objectives (risk-based remediation standards).
- For the Human Health Risk Assessment (HHRA), HC can review the statement of work, provide a technical review of the draft and final report, and provide advice on standard or more complicated aspects of HHRA (including, but not limited to, how to incorporate bioavailability of substances in soil to reduce remediation costs, how to address short-term exposure in a fiscally responsible manner, and how to ensure protection of human health).

- Provide advice on and/or review of HHRA and RAPS or RMPs as they pertain to human health.
- Provide advice on human health impacts associated with remedial options and on mitigating human health impacts on a technology- and site-specific basis.
- Participate in site visit activities.
- Provide advice on mitigation options to reduce human health exposure as they relate to site contamination and/or remediation options.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Assist throughout Step 7 including the evaluation of remedial options, which may include the use of project management and database tools; innovative procurement; and awareness of innovative, green, sustainable remediation approaches.
- Assist in project planning, including developing scope of work, work breakdown structure, schedule development, cost estimating and budgeting, quality planning, communications planning, risk identification and response, and procurement planning.

How the FCSAP Secretariat can assist

- Provide clarification on the application of the Eligible Cost Guidance, v. 5.0 document (FCSAP, update in progress) as required.

Supporting documents and tools specific to Step 7

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- CCME Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report (CCME, 1993)
- CCME Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries (CCME, 1993)
- Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada (CCME, 1996)
- Canada-Wide Standard for Petroleum Hydrocarbons Spreadsheet Model (CCME, 2008-2009)
- Canadian Environmental Quality Guidelines
    - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)
    - A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)
    - A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
    - A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)
- CCME Canadian Environmental Quality Guidelines (Website)

Federal Contaminated Sites Action Plan (FCSAP) Guidance

- FCSAP Guidance Document on Statements of Work for Ecological Risk Assessments (ERAs) at Federal Sites (FCSAP, 2011)
- FCSAP Ecological Risk Assessment (ERA) Guidance (FCSAP, 2012)
  - Module 1: Toxicity Test Selection and Interpretation (FCSAP, 2010)
  - Module 2: Selection or Development of Site-specific Toxicity Reference Values (FCSAP, 2010)
  - Module 3: Standardization of Wildlife Receptor Characteristics (FCSAP, 2012)
  - Module 4: Causality Assessment: Determining the Causes of Impairment at Contaminated Sites: Are Observed Effects Due to Exposure to Site-Related Chemicals or Due to Other Stressors? (FCSAP, 2013)
  - Module 5: Defining Background Conditions and Using Background Concentrations (FCSAP, 2015)
- Federal Interim Groundwater Guidelines (FCSAP, 2016)
  - Federal Interim Groundwater Guidelines Update (FCSAP, 2016)
- Guidance for Site Closure Tool at Federal Contaminated Sites (SCT), including Tools for Risk Assessment Validation (TRAV) (FCSAP, 2012)
- Federal Guidance for Estimating Remediation Liabilities at Federal Contaminated Sites (FCSAP, 2015)

Other Guidance and Tools

- Accounting Standard 3.1 – Treasury Board – Capital Assets (TBS, 2001)
- Accounting Standard 3.6 - Treasury Board– Contingencies (TBS, 2006)
- Federal Guidelines for Landfarming Petroleum Hydrocarbons Contaminated Soils (FCSAP, 2006, Editorial Update 2013)
- Directive on Contingencies (TBS, 2009)
- Guidance on Human Health Risk Assessment for Country Foods ($HHRA_{Foods}$) (HC, 2010)
- Supplemental Guidance on Developing a Contract Statement of Work for Human Health Preliminary Quantitative Risk Assessment (PQRA) and Detailed Quantitative Risk Assessment (DQRA) (HC, 2010)
- Fisheries and Oceans Canada (DFO) Pathways of Effects (website) (DFO, 2011)
- Guidance and Orientation for the Selection of Technologies (GOST) (PSPC/NRC, 2012)
- Guidelines for Canadian Drinking Water Quality (HC, 2014)
- For Human Health Risk Assessment (HHRA): Federal Contaminated Site Risk Assessment in Canada:
  - Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0 (HC, 2012) available on request from cs-sc@hc-sc.gc.ca,
  - Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0 (HC, 2010)
  - Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0 (HC, 2010)
  - Part V Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals ($DQRA_{CHEM}$) (HC, 2010)
  - Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment ($DQRA_{RAD}$) (HC, 2010)
  - Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites (HC, 2010)
- FCSAP Sediment Remediation Conceptual Cost Estimation Tool (PSPC, 2013)
- FCSAP Long Term Monitoring (LTM) Planning Guidance (FCSAP, 2013)
- Remediation Liabilities Related to Contaminated Sites: A Supplement to the Financial Information Strategy (FIS) Manual (TBS, 2010)

- Sustainable Remediation Forum (SuRF) Canada (Website)

Legislation

- Canadian Environmental Assessment Act (CEAA, 2012)
- Canadian Environmental Protection Act (CEPA, 1999)

Step 8: Implement Remediation/Risk Management (R/RM) Strategy

Step 8, which is based on the analysis and planning outcomes from Step 7, involves implementing the Remediation/ Risk Management Strategy (which includes the Remedial Action Plan (RAP) and Remediation Management Plan (RMP) to reduce the risk from contaminants at the site to acceptable levels. Other responsibilities include:

- Meeting requirements under the Canadian Environmental Assessment Act (CEAA 2012);
- Obtaining all permits and approvals required to undertake any work at the site;
- Developing sustainable contracting clauses;
- Selecting the contractor;
- Conducting operations, maintenance and monitoring during implementation of the remediation during the RAP/RMP; and
- Verifying the efficacy of the RAP/RMP.

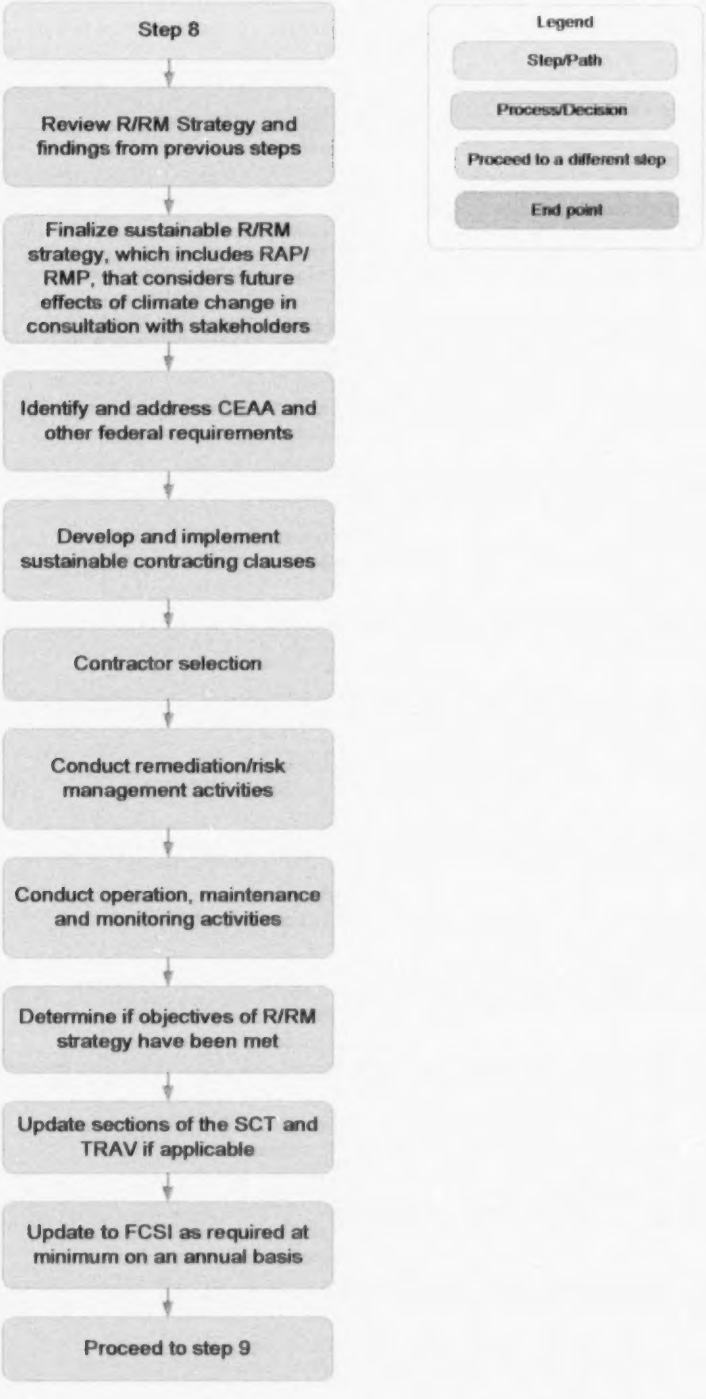
This step should include strict documentation control and adherence to the remediation/risk management (R/RM) objectives, as any unanticipated occurrences will require modification of the RAP and potential re-evaluation of the technologies applied. Stakeholders should be consulted as appropriate. Effects of climate change should be taken into consideration, and sustainable R/RMs should be included at all stages of the RAP/RMP. If it is determined that the remediation objectives will not be met, a full review of the R/RM Strategy and RAP/RMP for the site is required. It may be necessary to revisit earlier steps to determine what supplemental work is required or to determine if the site management strategy needs to be refined.

Key decision(s):

- Categorize site strategy based on approach and determine whether short, medium, or long-term plans will be affected by climate change by reviewing the assessment conducted in Step 7.
- Develop integrate sustainable contracting clauses.
- Determine if the performance expectations of the R/RM strategy have been met.

Step 8: Implement Remediation/Risk Management (R/RM) Strategy

All activities in Step 8 should consider the future impacts of climate change on the site and should aim to use sustainable approaches.


Step 8
Review R/RM Strategy and findings from previous steps
Finalize sustainable R/RM strategy, which includes RAP/ RMP, that considers future effects of climate change in consultation with stakeholders
Identify and address CEAA and other federal requirements
Develop and implement sustainable contracting clauses
Contractor selection
Conduct remediation/risk management activities
Conduct operation, maintenance and monitoring activities
Determine if objectives of R/RM strategy have been met
Update sections of the SCT and TRAV if applicable
Update to FCSI as required at minimum on an annual basis
Proceed to step 9
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Provide advice during implementation of the R/RM strategies related to:
  - mitigation measures and compliance requirements under the *Fisheries Act*;
  - effectiveness and compliance monitoring;
  - unforeseen issues; and
  - revisions to the sampling and monitoring plans, if required.
- Provide support to the public engagement process.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice related to the implementation of R/RM strategies (specific to potential environmental)
- Provide advice on compliance requirements under the *Fisheries Act* and other ecological requirements.
- Provide advice on revising the design, implementation and objectives for the long-term management plan including a long-term monitoring plan (to be developed and implemented in Step 10).
- Provide advice on the preparation of the site closure report and assist with the Site Closure Tool (SCT) (FCSAP, 2012) including the Tool for Risk Assessment Validation (TRAV) an optional component of the SCT.

How Health Canada (HC) expert support can assist

- Provide advice related to the implementation of R/RM strategies (specific to potential human health impacts).
- Provide advice and support in the determination of the site's significant environmental effects as defined under the Canadian Environmental Assessment Act, 2012 (CEAA 2012).
- Provide advice and support on risk communication to stakeholders (including the general public).
- Provide advice on the accuracy of model and other assumptions made during the Human Health Risk Assessment (HHRA) and the RM Strategy.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Provide advice on, among other things, finalizing the RAP/RMP, developing tender specifications, selecting contractors, providing oversight of remedial activities, and completing the SCT. Ensure that the monitoring and control of the site, such as the status, scope, schedule, communication, risk control and lessons learned, are complete.

How the FCSAP Secretariat can assist

- Provide support to custodian as they complete the SCT/TRAV and assesse effectiveness of R/RM strategy.

Supporting documents and tools specific to Step 8

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Legislation

- *Canada Wildlife Act(1985)*
- *Fisheries Act (1985)*
- *Canadian Environmental Assessment Act (CEAA) 1992, CEAA* 2012
- *Migratory Birds Convention Act (1994)*
- *Canadian Environmental Protection Act (CEPA), 1999*
- *Species at Risk Act* (SARA) (2002)

General Guidance

- Federal Guidelines for Landfarming Petroleum Hydrocarbons Contaminated Soils (FCSAP, 2006, Editorial Update 2013)
- Project/Program Risk Management Guidance for Federal Contaminated Sites Remediation/Risk Management (R/RM) Projects Guidance and Orientation for the Selection of Technologies (GOST) (PSPC/NRC, 2012)
- Site Closure Tool (SCT) and Tool for Risk Assessment Validation (TRAV) (FCSAP, 2012)
- Remediation Checklist (internal, Health Canada)
- Contaminated Site Remediation Projects Roadmap (Website) (PSPC)

Other

- Fisheries and Oceans Canada (DFO) Pathways of Effects (DFO, 2011)
- Sustainable Remediation Forum (SuRF) Canada (Website)

Step 9: Confirmatory Sampling and Final Reporting

Step 9 involves confirming the achievement of remediation/risk management (R/RM) objectives following the implementation of the R/RM Strategy (which includes the Remedial Action Plan (RAP) and Remediation Management Plan (RMP)).

Confirmatory sampling is completed to demonstrate that the contamination has been removed or stabilized effectively and that the clean-up R/RM objectives have been attained.

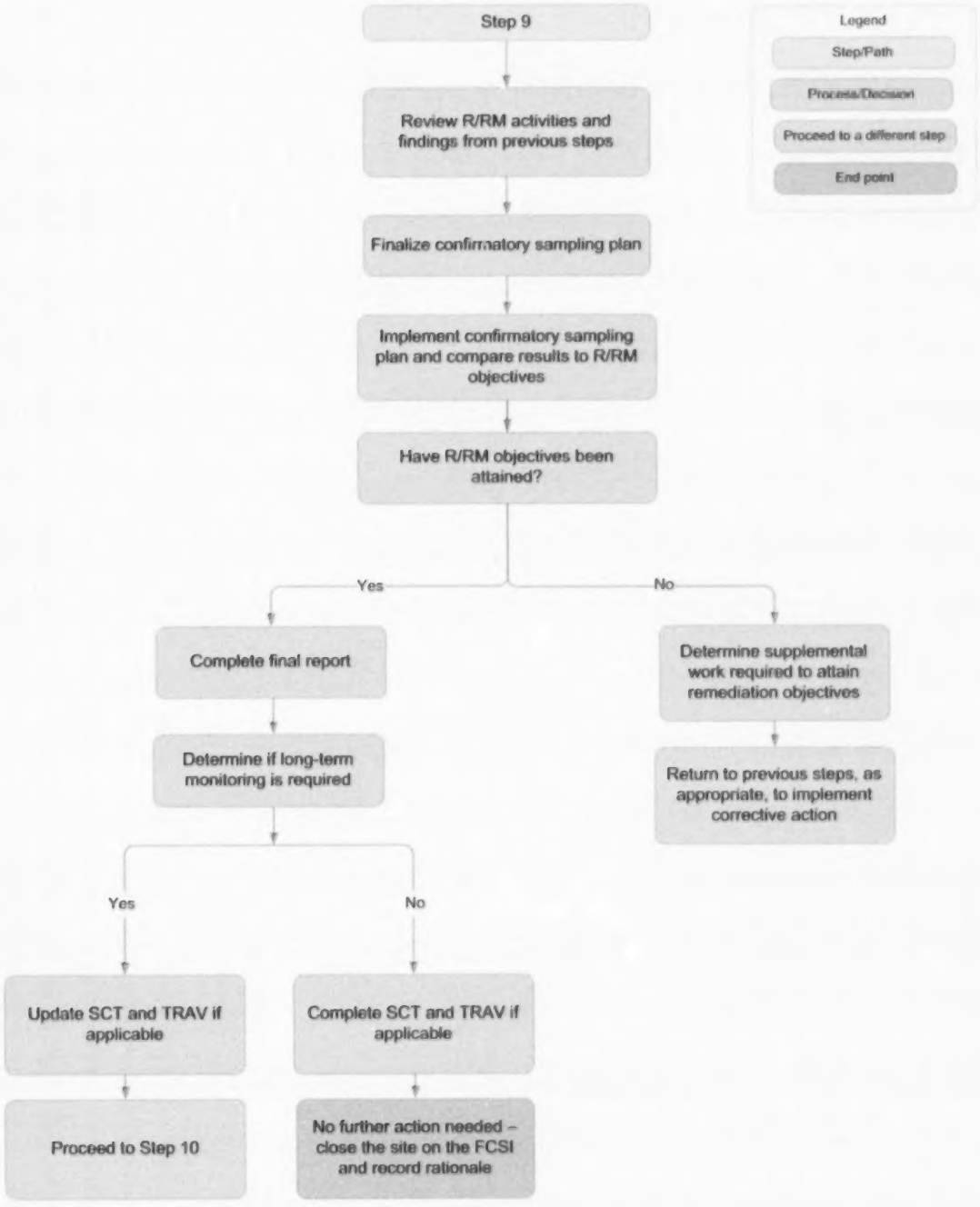
The site conditions as well as activities carried out during site decommissioning and clean-up, including drawings, records, and monitoring data will be documented in a report. At this step it is important to explain how climate change effects may have impacted the progress of the R/RM activities and whether potential climate change effects are expected to have significant future impacts with respect to the site's R/RM strategies and/or long-term monitoring (LTM) strategy.

Closure reporting using the Site Closure Tool (SCT) (FCSAP, 2012) to document the reduction of risk to acceptable levels will be completed and submitted to the Federal Contaminated Sites Action Plan (FCSAP) Secretariat (mandatory for FCSAP-funded sites), if it is determined that no further action is required, and to profile the use of sustainable approaches at the site. For sites that require additional R/RM activities or LTM, this information would also be recorded in the site closure report in preparation for closure in the future.

Key decision(s):

- Evaluate the success of the site management strategy implementation.
- Determine whether the site can be closed or whether additional work (e.g., continued R/RM or LTM) is required.
- Document climate change assessment and analysis, especially where expected climate change effects would encourage use of LTM.
- When required, begin planning sustainable LTM techniques that minimize energy usage and waste production.

Step 9: Confirmatory Sampling and Final Reporting


Step 9
Review R/RM activities and findings from previous steps
Finalize confirmatory sampling plan
Implement confirmatory sampling plan and compare results to R/RM objectives
Have R/RM objectives been attained?
Yes
No
Complete final report
Determine if long-term monitoring is required
Yes
No
Update SCT and TRAV if applicable
Proceed to Step 10
Complete SCT and TRAV if applicable
No further action needed – close the site on the FCSI and record rationale
Determine supplemental work required to attain remediation objectives
Return to previous steps, as appropriate, to implement corrective action
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Review and provide advice on the results of the confirmatory sampling.
- Advise on the effectiveness of monitoring in protecting fish and fish habitat.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the FCSAP (FCSAP, 2011).
- Provide advice on the design and expectations associated with the LTM plan.

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice on the design, implementation and results of confirmatory sampling.
- Provide advice on the preparation of the site closure report and assist with the Site Closure Tool (SCT) including the Tool for Risk Assessment Validation (TRAV) (2012), an optional component of the SCT.

How Health Canada (HC) expert support can assist

- Provide advice on the design and implementation of confirmatory sampling.
- Provide advice on the preparation of closure reporting and on the reporting of risk reduction.
- Provide advice on ongoing site work and long-term management.
- Provide assistance with interpreting LTM results and reports as they relate to human health.

How Public Services and Procurement Canada (PSPC) expert support can assist

- Can assist in confirming whether the R/RM objectives were met, including the completion of the sampling plan.
- Assist in confirming that no further action is necessary and in documenting completion through the SCT.

How the FCSAP Secretariat can assist

- Offer support by providing clarification on the application of the Eligible Cost Guidance, v. 5.0 (FCSAP, update in progress) document as required, and assist in reporting on the Federal Contaminated Sites Inventory (FCSI).

Supporting documents and tools specific to Step 9

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Canadian Council of Ministers of the Environment (CCME) Guidance

- CCME Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report (CCME, 1993)
- CCME Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries (CCME, 1993)
- CCME Canadian Environmental Quality Guidelines
    - A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007)

- A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006)
- A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995)
- A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)

Other Guidance

- Federal Guidelines for Landfarming Petroleum Hydrocarbons Contaminated Soils (FCSAP, 2006, Editorial Update 2013)
- Federal Interim Groundwater Guidelines, (FCSAP, 2016)
    - Federal Interim Groundwater Guidelines Update (FCSAP, 2016)
- Guidelines for Canadian Drinking Water Quality (HC, 2014)
- Site Closure Tool (SCT), including the Tool for Risk Assessment Validation (TRAV) (FCSAP, 2012)
- FCSAP Long Term Monitoring Planning Guidance (FCSAP, 2013)

Step 10: Long Term Monitoring (LTM) (if required)

The objective of Step 10 is to implement a long-term monitoring (LTM) strategy at sites where the remediation/risk management (R/RM) objectives have been met but where conditions are such that the site could not be closed. For example, a risk management site would likely require long term monitoring. Long-term monitoring (LTM) may not be required at all sites. According to the 10-step Approach, LTM is meant to confirm that the nature and extent of the remediation activities have been carried out as per the site management goals, and that the objectives of the remediation or risk management strategy **continue** to be met over time to protect human health and the environment. Sustainable methods for site monitoring and contracting should be implemented as part of the LTM. Climate change effects should be considered during the development and assessment of the monitoring program in order to take potential changes in site conditions and exposure pathways into account. Stakeholders should be consulted as appropriate.

LTM objectives must be achieved and verified before a site can be closed, indicating that no further action is required. However, at some sites, perpetual monitoring may be required.

Once the LTM Strategy has been completed satisfactorily and the site can be closed, a closure tool should be completed, or updated. For FCSAP funded sites (R/RM activities) the Site Closure Tool (SCT) (FCSAP, 2012) must be completed and submitted to the FCSAP Secretariat.

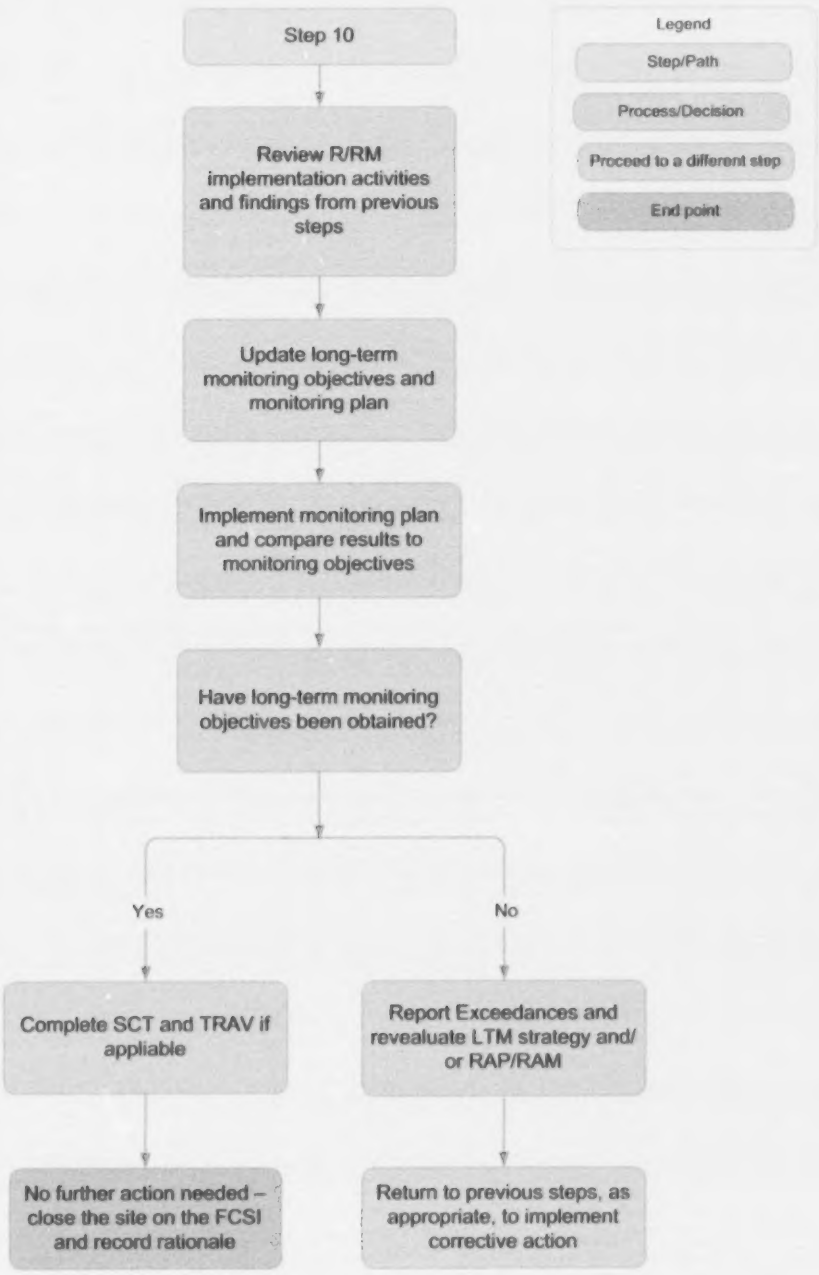
If LTM objectives have not been met (e.g. monitoring results indicate exceedance of objectives), the exceedances should be reported to the appropriate level of management and custodians should re-evaluate the LTM Strategy and/or the Remedial Action Plan (RAP)/Risk Management Plan (RMP) (see Step 7).

Key decision(s):

- Decide whether the LTM plan, developed in Step 7, is still applicable.
    - Is the remedy functioning as intended by the R/RM plan?
    - Are the exposure assumptions, toxicity data, cleanup levels, and Remediation Action Plan/Risk Management Plan objectives used during Step 7 still valid?
    - Has any other information come to light that could call into question the protectiveness of the remedy?
- Decide when LTM is no longer required.
- Consider climate change effects during LTM planning, including possible permafrost loss or increases and decreases in infiltration rates, and
- Plan and implement sustainable LTM techniques, where feasible, that minimize energy usage and waste production.

Step 10: Long-Term Monitoring (if required)

All activities in Step 10 should consider the future impacts of climate change on the site and should aim to use sustainable approaches.


Step 10
Review R/RM implementation activities and findings from previous steps
Update long-term monitoring objectives and monitoring plan
Implement monitoring plan and compare results to monitoring objectives
Have long-term monitoring objectives been obtained?
Yes
No
Complete SCT and TRAV if appliable
Report Exceedances and revealuate LTM strategy and/ or RAP/RAM
No further action needed – close the site on the FCSI and record rationale
Return to previous steps, as appropriate, to implement corrective action
Legend
Step/Path
Process/Decision
Proceed to a different step
End point

How Fisheries and Oceans Canada (DFO) expert support can assist

- Provide advice during the design and development of a LTM program (e.g., selecting monitoring targets/endpoints and monitoring plans).
- Provide support for public engagement activities (e.g., help with the interpretation and communication of results).
- Assist with interpreting LTM results and reports.
- Provide advice on adaptive management and possible modifications to the monitoring plan.
- Provide assistance in applying the Framework for Addressing and Managing Aquatic Contaminated Sites under the Federal Contaminated Sites Action Plan (FCSAP, 2011).
- Provide assistance with interpreting LTM results and reports.

How Environment and Climate Change Canada (ECCC) expert support can assist

- Provide advice during the design and development of a LTM plan.
- Provide advice on establishing procedures for identifying decision criteria prior to LTM data collection.
- Provide assistance with interpreting LTM results and reports.
- Provide advice on the need to continue monitoring.

How Health Canada (HC) expert support can assist

- Provide advice on the need for LTM and on the design of the monitoring plans, including the need for risk communication with stakeholders and those affected, for the duration of the monitoring program (if necessary).

How Public Services and Procurement Canada (PSPC) expert support can assist

- Assist with the update of the LTM plan and with continual monitoring and the Site Closure Tool (SCT) (FCSAP, 2012) when applicable.

How the FCSAP Secretariat can assist

- Provide clarification on the application of the Eligible Cost Guidance document, v. 5.0 (FCSAP, update in progress) as required.

Supporting documents and tools

Please also refer to the list of "Supporting documents and tools useful throughout the 10-step process" at the beginning of the document.

Guidance

- Site Closure Tool (SCT), including the Tool for Risk Assessment Validation (TRAV) (FCSAP, 2012)
- FCSAP Long Term Monitoring (LTM) Planning Guidance (FCSAP, 2013)

Appendix A: Incorporating Sustainability in Contaminated Sites Management

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1 Introduction

The main objectives of the Federal Contaminated Sites Action Plan (FCSAP) are to reduce the human health and environmental risks and the financial liabilities associated with federal contaminated sites. One of the priorities under the program is to strengthen consideration of the environmental and socio-economic effects of contaminated sites management at these sites. Furthermore, the Treasury Board Policy on Management of Real Property, which outlines the requirements associated with federal contaminated site management, states that the objective of the policy is "to ensure real property is managed in a sustainable and financially responsible manner, throughout its life cycle, to support the cost-effective and efficient delivery of government programs."

The FCSAP Secretariat has developed tools, guidance and training to encourage the use of sustainable approaches when managing federal contaminated sites, including the addition of sustainability considerations into the FCSAP Decision-Making Framework (DMF). This appendix provides additional resources to help custodians implement sustainable practices listed in the steps of the DMF. The sections below present general information on sustainable contaminated site management, the benefits associated with incorporating sustainable approaches, the best management practices associated with implementing those approaches, as well as a number of references for guidance documents and case studies that further describe these approaches and best management practices.

2 Principles of Sustainable Contaminated Site Management

Sustainable contaminated site management includes the analysis of the "environmental, social and economic impacts of a project to ensure an optimal outcome, while being protective of human and environmental health, both at a local level and for the larger community" (extracted from Sustainable Remediation Forum (SuRF) Canada, 2012 definition of sustainable remediation).

Sustainable contaminated site management considers implementing sustainable approaches throughout each of the following project phases:

- Preliminary Project Planning (DMF Steps 1 & 2)
- Initial and Detailed Testing Program and Site Assessment (DMF Steps 3 to 6)
- Remediation / Risk Management Strategy Development (DMF Step 7)
- Remediation / Risk Management Strategy Implementation (DMF Step 8)
- Confirmatory Sampling and Final Reporting / Long-term Monitoring (DMF Steps 9 and 10)

By integrating sustainable approaches and activities throughout the FCSAP 10-step approach (i.e., planning through monitoring as listed above), the environmental footprint for each stage can be reduced. Site managers can choose approaches that not only manage or eliminate the

contamination risks but also maximize the overall environmental, social and economic benefits associated with those approaches.

3 Benefits of Sustainable Contaminated Site Management

Incorporating sustainability into contaminated sites management can have many benefits, including:

- Reduced:
  - Project costs
  - Energy consumption
  - Emissions
  - Material consumption
  - Water use
  - Waste generation
  - Dust
  - Noise
  - Vehicle congestion
- Increased
  - Use of renewable energy
  - Ecosystem and habitat protection
  - Stakeholder / public involvement and confidence
  - Use of local services and service providers
  - Local employment

In many cases, site challenges can be overcome by, or be drivers for, the use of sustainable approaches. For example, sites with large areas of contamination or in sensitive ecosystems, remote and northern locations and/or with lack of access to electrical power can benefit from sustainable approaches such as:

- The use of renewable energy sources such as wind and solar power, which will reduce energy consumption;
- The use of on-site sampling and analytical techniques, which will reduce the need to transport large numbers of samples off-site;
- The use of more passive in-situ remediation / risk management options, which will use less energy.

4 Best Management Practices for Implementing Sustainable Approaches

The sustainability approaches identified in the DMF flowcharts are described in more detail in the "Sustainability Summary Tables" presented in the sections below. Various best management practices (BMPs) are presented to assist site managers to implement the sustainability approaches into their projects.

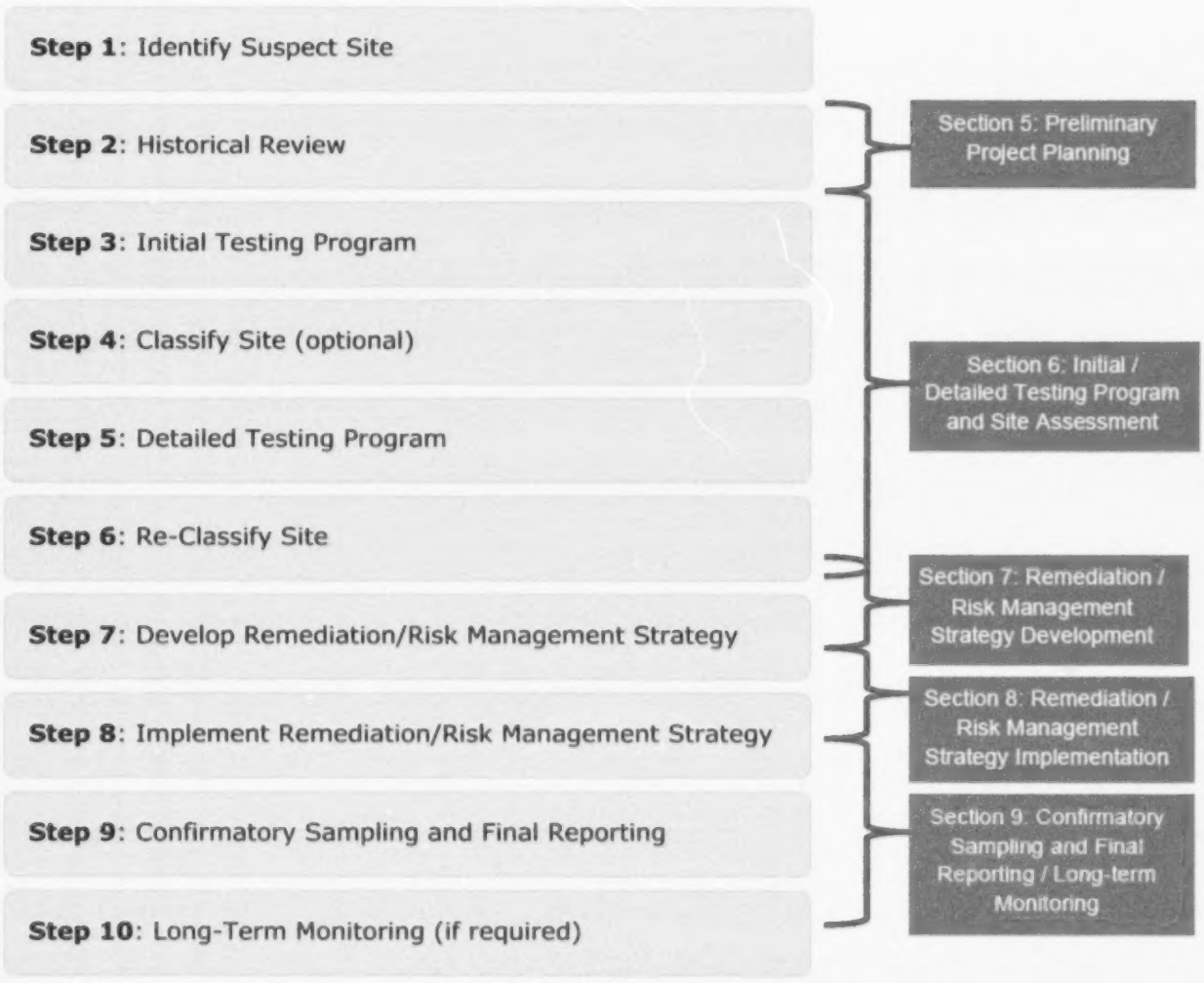
Step 1: Identify Suspect Site
Step 2: Historical Review
Step 3: Initial Testing Program
Step 4: Classify Site (optional)
Step 5: Detailed Testing Program
Step 6: Re-Classify Site
Step 7: Develop Remediation/Risk Management Strategy
Step 8: Implement Remediation/Risk Management Strategy
Step 9: Confirmatory Sampling and Final Reporting
Step 10: Long-Term Monitoring (if required)
Section 5: Preliminary Project Planning
Section 6: Initial / Detailed Testing Program and Site Assessment
Section 7: Remediation / Risk Management Strategy Development
Section 8: Remediation / Risk Management Strategy Implementation
Section 9: Confirmatory Sampling and Final Reporting / Long-term Monitoring

Figure 4-1: Alignment of Sustainability Best Management Practice Sections with FCSAP 10-Step Process

Figure 4-1 shows the alignment between the FCSAP 10-Steps described in the DMF and the sections in this document with the best management practices for those steps.

The BMPs proposed have varying degrees of complexity. Some of them can be easily applied with minimal time and resources, while others take planning and require additional resources in order to make them more feasible for larger, more complex sites. To assist with the selection of BMPs that are commensurate with the complexity of a site, in the tables below, each BMP is assigned a level as follows:

- Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
- Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

Within each Sustainability Summary Table, there are links to the reference sections listing guidance documents and, where available, case studies related to the best management practices presented in the Tables.

5 Preliminary Project Planning (DMF Steps 1 and 2)

5.1 Sustainable Best Management Practices

Preliminary Project Planning (DMF Steps 1 and 2) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
5.1.1 Preliminary Sustainability Plan Development *(References)*		
Develop a Preliminary Sustainability Plan that includes the general requirements set out in the Federal Sustainable Development Strategy and specifically outlines the requirements for the project related activities outlined below. The plan should also require any consultants and contractors working on the project to have the following elements incorporated into their work plans and their company's Environmental Management Systems:	X	X
5.1.2 On-site / office waste reduction activities *(References)*		
• Reduce water use, waste generation and reuse and recycle wastes (e.g., office waste, demolition waste) generated on site.	X	X
• Recycle paper and other materials	X	X
• Use recycled paper	X	X
• Avoid printing when possible	X	X
• Use reusable cups	X	X
5.1.3 Transportation related activities *(References)*		
• Avoid idling vehicles	X	X
• Use alternative worker transport methods (e.g., carpooling, cycling)		X
• Use fuel efficient or hybrid vehicles		X
• Use alternative fuel (i.e., biofuels)		X
5.1.4 On-site equipment activities *(References)*		
• Avoid idling equipment	X	X
• Optimize and maintain equipment regularly	X	X
• Use energy-efficient equipment		X
• Use alternative fuel sources (i.e., biofuels) to power equipment		X
• Incorporate renewable energy sources (e.g., wind , solar)		X
• Use equipment with low air emissions and / or enhanced emission controls		X

Preliminary Project Planning (DMF Steps 1 and 2) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
5.1.5 Evaluate Sustainability Options for the Project *(References)*		
• Identify indicators and metrics that will be measured throughout the project in order to monitor and report on the use of sustainable approaches	X	X
• Use qualitative or semi-qualitative tools for evaluating the sustainability of options for managing the contaminated site project.	X	X
• Use quantitative (i.e., life-cycle analysis) tools for evaluating the sustainability of options for managing the contaminated site project.		X
5.1.6 Other sustainable site management considerations *(References)*		
• Determine the best and most sustainable potential future uses for the site	X	X
• Ensure habitat and eco-system protection	X	X
• Examine interim use opportunities (i.e., wind or solar energy generation on unused portions of site)		X
• Investigate opportunities for local employment and other socio-economic benefits		X
• Consider climate change adaptation		X
• Engage contractors / stakeholders to obtain their input on implementing sustainable approaches for the specific site		X

* Notes
Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

5.2 References

Preliminary Project Sustainability Plan Development - References (Section 5.1.1, 7.1.2 & 8.1.1)

General Guidance

Association of State and Territorial Solid Waste Management Officials (ASTSWMO). Remediation and Reuse Focus Group. *Green Remediation at Federal Facility Cleanups - Final Report*. (2011) (http://www.astswmo.org/Files/Policies_and_Publications/Federal_Facilities/2011.01_FINAL_Green_Remediation_at_FF.pdf)

This document provides a summary of how various U.S. federal departments have integrated sustainable remediation into policies. Though many do not have an official policy document directly concerning sustainable remediation, many relay back to the U.S Directive #EO 13423 to implement green initiatives such as renewable energy and green products. Provides links to available documents and tools from U.S. EPA, Department of Defense, U.S. Air Force, U.S. Navy, and U.S. Army.

ASTM International. *ASTM E2876 - 13 - Standard Guide for Integrating Sustainable Objectives into Cleanup*. (2013) (http://www.astm.org/Standards/E2876.htm) (fee for download)

This guide presents a framework that allows and encourages the user to address sustainable aspects (environmental, economic and social) within cleanup projects. The user may implement this guide to integrate sustainable objectives into cleanup while working within applicable regulatory criteria.

ASTM International. *ASTM E2893 - 13e1 - Standard Guide for Greener Cleanups*. (2013) (http://www.astm.org/Standards/E2893.htm) (fee for download)

This guide provides a process for identifying, prioritizing, selecting, implementing, documenting, and reporting activities to reduce the environmental footprint of a cleanup.

Australian Government Department of Defence. *Guidelines for consideration of sustainability in remediation of contaminated sites*. (2010) (http://www.defence.gov.au/estatemanagement/governance/policy/environment/contamination/docs/sustainabilityremediationguidelines.pdf)

This guideline is intended for use by project development and environmental managers and their consultants who are responsible for making decisions regarding works and the remediation of Defence sites. It outlines the Defence framework for implementation of sustainability principles in contamination management including identification of the key property life cycle points at which to consider sustainability, and a framework for the consideration of sustainability in the broader contamination management options assessment process.

A broad remediation options assessment framework is presented that outlines the key requirements for contamination management to be met prior to evaluation of the sustainability of a remediation approach from an environmental, social and economic perspective. Three Defence case studies are presented that have evaluated remediation options, taking into consideration the environmental, social and economic benefits and dis-benefits that may ensue. The level of assessment required at this stage and the complexity of evaluation methods applied have to be commensurate with the size and nature of the project.

Bardos, P. et al. *Applying Sustainable Development Principles to Contaminated Land Management Using the SURF-UK Framework*. Remediation. (2011) (https://www.claire.co.uk/component/phocadownload/category/8-initiatives?download=220:surf-uk-applying-sustainable-development-principles-march-2011)

This paper suggests several mechanisms for increasing the use and efficacy of sustainable remediation, sustainable management and sustainability assessment in the remediation industry. The paper argues that setting out clearly defined steps for considering sustainability throughout the remediation process provides a net-benefit approach to management and whether the costs of sustainable remediation are greater than the benefits to society.

Ellis, D.E. and Hadley P.W. *Sustainable Remediation White Paper – Integrating Sustainable Principles, Practices, and Metrics into Remediation Projects.* Remediation. (2009) (http://www.sustainableremediation.org/remediation-resources/)

This white paper includes the history of the Sustainable Remediation Forum (SuRF) and sustainable remediation as well as outlining major issues that might initially limit the efficacy of sustainable remediation implementation. The paper also outlines applicable legislation at both federal and state levels as well as internationally (including Canada).

Federation of Canadian Municipalities (FCM). *FCM Incorporating Sustainability into Brownfield Remediation Web Page.* (2014) (http://www.fcm.ca/home/programs/green-municipal-fund/get-started-today/revitalize-your-brownfields/sustainable-remediation/incorporating-sustainability-into-brownfield-remediation.htm)

FCM's Green Municipal Fund offers funding and knowledge to municipal governments and their partners for brownfield planning, assessment and remediation activities. To assist in reaching this goal, this web page has a series of sustainable remediation information sheets that are accessible from this web page. (Individual sheets are listed in the applicable reference sections below.)

Interagency Technology and Regulatory Council (ITRC). *Green and Sustainable Remediation: A Practical Framework. Technical/Regulatory Guidance. (*2011) (http://www.itrcweb.org/GuidanceDocuments/GSR-2.pdf)

This ITRC document assists the remediation industry with the integration of green and sustainable practices into existing site investigation and remediation programs. It explains a Green and Sustainable Remediation (GSR) framework that can be incorporated into a site clean-up. The GSR framework builds three key aspects: environmental, social and economical into sustainable site remediation. The GSR framework is flexible and scalable to each phase of the remedial process and include aspects related to planning, performance metrics, and analytical tools.

Interagency Technology and Regulatory Council (ITRC). *Green and Sustainable Remediation: State of the Science and Practice (GSR-1). (*2011) (http://www.itrcweb.org/GuidanceDocuments/GSR-1.pdf)

In this technology overview document, the ITRC introduces the concept of "green and sustainable (GSR) remediation" and charts its current status. The document provides some basic definitions and describes some of the approaches of different agencies, states, and other entities. The document is intended to educate and inform state regulators and other stakeholders in the concepts and challenges of GSR.

Interagency Technology and Regulatory Council (ITRC). *Green and Sustainable Remediation Training Webinars.* (no date) (http://www.itrcweb.org/Training/ListEvents?TopicID=9&SubTopicID=15)

This site provides a series of webinars related to green and sustainable remediation.

Minnesota Pollution Control Agency. *Greener Practices for Business, Site Development, and Site Cleanups: A Toolkit.* (no date) (http://www.pca.state.mn.us/index.php/topics/preventing-waste-and-pollution/sustainability/greener-practices-toolkit/greener-practices-for-business-site-development-and-site-cleanups-a-toolkit.html)

This website is a toolkit intended to expand the use of greener practices in Minnesota. The site showcases examples and best management practices that have been used in the state of Minnesota.

Network for Industrially Contaminated Land in Europe (NICOLE). *Road Map for Sustainable Remediation.* (2010)
(http://www.nicole.org/uploadedfiles/2010-wg-sustainable-remediation-roadmap.pdf)

The NICOLE 'Road Map' is a single, structured process with a series of steps to ensure a consistent and collaborative approach to sustainability decision-making. It is intended to support robust and durable decisions, regardless of the project size. The roadmap breaks sustainable remediation into sustainability management (SM) and sustainability assessment (SA). SA is the process of understanding and measuring possible outcomes based on the economic, social and environmental elements of a project in cooperation with stakeholders. SM is the integration of SA into contaminated site management decision-making. The roadmap also presents the concept of a 'sustainability gain' (i.e, where net outcomes from the approaches applied are positive.

New York Environmental Protection Agency. *Green Remediation Program Policy.* (2011)
(http://www.dec.ny.gov/docs/remediation_hudson_pdf/der31.pdf)

This policy sets out the requirements associated with the application of green remediation techniques and consideration of sustainability objectives. The policy outlines easy-to-implement techniques as well as general concepts and methods of prioritizing/weighing applicable metrics when determining remedial action. The policy requires documentation of green remediation efforts during project evaluation and review.

Reddy, K. and J. Adams. *Sustainable Remediation of Contaminated Sites.* Momentum Press. (2015)
(http://www.momentumpress.net/books/sustainable-remediation-contaminated-sites) (fee)

This book describes the key elements of sustainable remediation, including decision frameworks, qualitative and quantitative assessment tools, and multidisciplinary metrics. It also presents several case studies that include sustainable remediation solutions and highlight the challenges in promoting this practice. The case studies presented describe life cycle assessments comparing excavation and hauling with solidification and stabilization.

Ryan, J. et al. *Sustainable Remediation Panel – Screening and Selecting Green and Sustainable Best Management Practices.* Remediation. (2011) (http://onlinelibrary.wiley.com/) (fee applies)

This journal article describes the process taken by several remediation professionals from different firms (AECOM, CH2MHILL, and SCS Engineers) to rank and organize BMPs for their respective remediation projects.

Sustainable Remediation Forum (SuRF) Australia. *A Framework for Assessing the Sustainability of Soil and Groundwater Remediation.* (2011)
(https://landandgroundwater.softlinkhosting.com.au/liberty3/libraryHome.do)

This framework builds on the SuRF UK Framework for Incorporating Sustainable Development Criteria in Soil and Groundwater Remediation and applies it to the Australian context. The document describes sustainability assessment approaches that can be used during the two main stages where sustainable remediation decision making is applied: 1) project/plan design stage and 2) point of remediation selection and implementation.

Sustainable Remediation Forum (SuRF) U.S. *SURF US Website.* (no date)
(www.sustainableremediation.org)

This is the web site for SURF U.S., which promotes the use of sustainable practices during implementation of remedial action activities with the objective of balancing economic viability, conservation of natural resources and biodiversity, and the enhancement of the quality of life in surrounding communities.

Sustainable Remediation Forum (SuRF) U.S. *Framework for Integrating Sustainability Into Remediation Projects.* Remediation 7-38. (2011) (http://www.sustainableremediation.org/remediation-resources/)

This journal article discusses the SURF US framework that integrates sustainability throughout the remediation project life cycle. The framework builds parameters based on environmental, social and economic impacts and helps form a structured planning strategy. Since remediation

project phases are interconnected with the larger remediation system, the framework is built on a systematic process-based approach through performing tiered sustainability evaluation.

Sustainable Remediation Forum (SuRF) UK. *SuRF-UK Sustainable Management Practices for Management of Land Contamination*. (2014)
(http://www.claire.co.uk/index.php?option=com_phocadownload&view=file&id=402:surf-uk-phase-3-bulletin&Itemid=230)

This document describes a simple process and presents associated activities to encourage sustainable thinking, decision-making and action across all land contamination management activities by using Sustainable Management Practices even for activities (e.g., project planning) that would not normally have a formal sustainability assessment. The practices presented are relatively simple, common sense actions that can be implemented at any stage in a land contamination management project to improve its environmental, social and/or economic performance". The document should be used in conjunction with the Sustainable Management Practices spreadsheet available from www.claire.co.uk/surfuk

Sustainable Remediation Forum (SuRF) UK. *SuRF U.K. Website & Roadmap*. (no date)
(https://www.claire.co.uk/projects-and-initiatives/surf-uk)

The SURF UK Website contains a wide range of information related to sustainable remediation. The site includes general information as well as summary of forum meetings, presentations, consultations as well as a series of framework and guidance documents developed by the group. The main page of the website provides a roadmap for navigating these materials.

U.S. Army Corps of Engineers (U.S.ACE). *Decision Framework for Incorporation of Green and Sustainable Practices into Environmental Remediation Projects. Environmental Interim Guidance Document 10-01. (*2010)
(http://static1.1.sqspcdn.com/static/f/361803/12807992/1308604751560/Footprint-LCA-20289_ftp.pdf?token=ELjDBw6BBjilmilOck3mHQ%2Bkiyo%3D)

The US Army Corps of Engineers Decision Framework explains the process of developing a tailored framework to the specific needs for site remediation. It builds on the EPA Green Remediation Primer document and incorporates the importance of including steps in the remediation process: air, water, land and ecosystems, materials and waste, energy and stewardship. This document, however, builds on those six components by adding worker safety as an element of green and sustainable remediation.

U.S. Army Corps of Engineers (U.S.ACE). *Evaluation of Consideration and Incorporation of GSR Practices in Army Environmental Remediation*. (2012)
(https://www.fedcenter.gov/Documents/index.cfm?id=22322)

This US Army Corps of Engineers study report presents a process for considering, incorporating, documenting, and evaluating the benefits of green and sustainable remediation practices

U.S. Environmental Protection Agency (U.S. EPA). *Implementing Greener Cleanups through ASTM's Standard Guide (E2893-13)*. On-line version of webinar delivered on November 17, 2015. https://clu-in.org/conf/tio/gcsg_111715/

The webinar provides an overview of the ASTM International Standard Guide for Greener Cleanups (E2893-13), which offers a step-wise approach for reducing the environmental footprint of site cleanup activities. Topics covered are: an overview of the Standard; how the Standard can guide project decisions; and a description of experiences in using the Standard at sites across the U.S. under state or federal cleanup programs.

U.S. Environmental Protection Agency (U.S. EPA). *Methodology for Understanding and Reducing a Project's Environmental Footprint*. (2012).
(https://www.epa.gov/sites/production/files/2015-04/documents/methodology_enivro_footprint.pdf)

This document provides an introduction to reducing negative environmental effects that might occur during site assessment, remediation, or non-time critical removal actions

U.S. Environmental Protection Agency (U.S. EPA). *Superfund Green Remediation Strategy. Office of Superfund Remediation and Technology Innovation. (*2010)
(http://www.epa.gov/superfund/greenremediation/sf-gr-strategy.pdf)

This document discusses the importance of developing a site remediation strategy that spans the life-cycle of the project and emphasizes that the strategy needs to take into consideration the concept of green remediation. The strategy focuses on cleanup activities and contains nine key actions that are categorized in three sections: policy and guidance development, resource development and program implementation and program evaluation. The nine key activities are: the role of remediation, compendium of protocols and tools, options that enable the use, address air pollutant emissions, develop pilot projects, establish opportunities in contracts, communicate and share success stories, roadmap for evaluating and evaluate.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation Focus, Contaminated Sites Clean-up Information.* (2016)
(http://www.clu-in.org/greenremediation/)

The US EPA web portal for green contaminated site remediation is a resource base that contains information regarding contaminates, technologies, issues, strategies & initiatives, vendors & developers, online webinar training seminars & events, and additional resources.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation Primer, Incorporating Sustainable Environmental Practices into Remediation of Contaminated Sites*. (2008)
(http://www.clu-in.org/download/remed/green-remediation-primer.pdf)

This document outlines the principles of green remediation and describes opportunities to reduce the footprint of cleanup activities throughout the life of a project. Best management practices outlined in this document help decision-makers identify new strategies in terms of sustainability.

U.S. National Academy of Sciences. *Sustainability Concepts in Decision-Making: Tools and Approaches for the US EPA*. National Academies Press. (2014)
(http://dels.nas.edu/Report/Sustainability-Concepts-Decision-Making-Tools/18949) (fee)

This report on Scientific Tools and Approaches for Sustainability presents the application of sustainability tools through case studies from EPA and elsewhere and in public-private collaborations. The report concludes that EPA has many opportunities to further apply sustainability tools and approaches across the spectrum of its activities, and it should do so as rapidly as is practicable.

U.S. Naval Facilities Engineering Command (NAVFAC). *Green and Sustainable Remediation Fact Sheet, NAVFAC (version 7).* (2014)
(https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/gsr.html#resources)

This Fact Sheet provides an overview of green and sustainable remediation (GSR) metrics. The sheet covers "GSR Metrics and Remedy Footprint Assessment Methodology", footprint reduction methods and a list of applicable resources.

U.S. Naval Facilities Engineering Command (NAVFAC). *Naval Facilities Engineering Command Green and Sustainable Remediation*. (no date)
(https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/gsr.html)

This web portal provides a range of resources associated with the application of NAVFAC's green and sustainable remediation (GSR) metrics and the SiteWise™ GSR Tool.

Wisonsin Environmental Protection Agency. *Wisconsin Initiative for Sustainable Remediation and Redevelopment (WISRR) - Green & Sustainable Remediation Manual. (*2012)
(http://dnr.wi.gov/files/pdf/pubs/rr/rr911.pdf)

This manual is a guide to sustainable remediation in the state of Wisconsin. It provides a detailed outline of drivers and metrics, sustainability considerations checklist, sustainability baseline development including the calculation of carbon footprint, categorization of sources, example

case design, remedial process optimization, alternative energy considerations and sustainability matrix.

Case Studies

Federal Contaminated Sites Action Plan (FCSAP). *Fort Nelson Airport Remediation Program Case Studies. (2014)*
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#fornelson)

This case study describes the remediation of several sites at the Fort Nelson airport, where approximately 153 000 cubic meters of soil is contaminated resulting from activities dating back to the Second World War. At this site, Transport Canada initiated a pilot project to identify and implement several best practices for sustainable remediation. Transport Canada implemented a Sustainability Management Plan that included: recycling and reuse of materials, prohibition on idling vehicles, alternative methods of transportation, such as carpooling and cycling, fuel-efficient heavy equipment, reporting of fuel consumption, and project-based accounting for greenhouse gas emissions.

On-site / Office Waste Reduction Activities - References (Section 5.1.2)

General Guidance

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Materials and Waste Management*. (2013)
(https://clu-in.org/greenremediation/)

These US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to material and waste reduction and management during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA), *Recycled Content (ReCon) Tool. (*2010)
(http://www3.epa.gov/epawaste/conserve/tools/warm/ReCon_home.html)

The ReCon Tool calculates GHG emissions and energy consumption related to purchasing and/or manufacturing activities using analyses of baseline and alternative recycled-content scenarios. Specifically, the tool can be used to calculate the tons of material reduced through purchase or use of items with recycled content

U.S. Environmental Protection Agency (U.S. EPA). *Waste Reduction Model (WARM). (*2012)
(https://www.epa.gov/warm)

The WARM model calculates GHG emissions of baseline and alternative waste management practices such as, source reduction, recycling, combustion, composting, and landfilling. The model calculates GHG emissions based on typical and alternative waste management strategies and includes 46 different material types as well as a variety of output units including MTCE, MTCO2E, and million BTU.

Case Studies

Federal Contaminated Sites Action Plan (FCSAP). *Fort Nelson Airport Remediation Program Case Study. (no* date)
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#fornelson)

This case study describes the remediation of several sites at the Fort Nelson airport, where approximately 153 000 cubic meters of soil is contaminated resulting from activities dating back to the Second World War. At this site, Transport Canada initiated a pilot project to identify and implement several best practices for sustainable remediation. Transport Canada implemented a Sustainability Management Plan that included: recycling and reuse of materials, prohibition on idling vehicles, alternative methods of transportation, such as carpooling and cycling, fuel-efficient heavy equipment, reporting of fuel consumption, and project-based accounting for greenhouse gas emissions.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Materials and Waste).* (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates best management practices. The table can be used to select profiles that highlight techniques for material and waste reduction. Included in the descriptions are innovative technologies and novel field methods.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Water).* (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates best management practices. The table can be used to select profiles that highlight techniques for water use reduction. Included in the descriptions are innovative technologies and novel field methods.

Transportation Related Activities - References (Section 5.1.3)

General Guidance

Natural Resources Canada. *Welcome to the Idle-Free Zone – Website.* (2014)
(http://www.nrcan.gc.ca/energy/efficiency/communities-infrastructure/transportation/idling/4397)

This web site contains graphic materials, articles, tools and templates to assist with the organization of a public education campaign related to anti-idling at a workplace or develop a larger-scale awareness and outreach campaign in a community.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Clean Fuel & Emission Technologies for Site Cleanup.* (2010)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers the use of clean fuels and emission control technologies during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Diesel Emissions Quantifier.* (2015)
(http://www2.epa.gov/cleandiesel/diesel-emissions-quantifier-deq)

This interactive tool can be used to evaluate clean diesel projects by estimating emission reductions, cost effectiveness, and health benefits.

U.S. Environmental Protection Agency (U.S. EPA). *Emission Facts - Idling Vehicle Emissions, Air and Radiation EPA420-F-98-014.* (1998)
(http://www3.epa.gov/otaq/consumer/f98014.pdf)

In cases were detailed specific emission estimates tailored to local conditions are not required, this tool can provide general idling emission estimates. This summary of idle emission factors can be used to obtain first-order approximations of emissions under idle conditions.

Case Studies

Federal Contaminated Sites Action Plan (FCSAP). *Fort Nelson Airport Remediation Program Case Study. (no* date)
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#fornelson)

This case study describes the remediation of several sites at the Fort Nelson airport, where approximately 153 000 cubic meters of soil is contaminated resulting from activities dating back to the Second World War. At this site, Transport Canada initiated a pilot project to identify and implement several best practices for sustainable remediation. Transport Canada implemented a Sustainability Management Plan that included: recycling and reuse of materials, prohibition on idling vehicles, alternative methods of transportation, such as carpooling and cycling, fuel-efficient heavy equipment, reporting of fuel consumption, and project-based accounting for greenhouse gas emissions.

On-site Equipment Activities - References (Section 5.1.4)

General Guidance

Interagency Technology and Regulatory Council (ITRC). *Remediation Process Optimization: Identifying Opportunities for Enhanced and More Efficient Site Remediation. (*2004)
(http://www.itrcweb.org/Guidance/GetDocument?documentID=78)

This guidance document provides information related to remediation process optimization (RPO), which can help save money, energy and time during remediation project particularly for large, complex sites.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Integrating Renewable Energy into Site Cleanup. (*2011)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to the use of renewable energy during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Re-Powering America's Land.* (no date)
(http://www2.epa.gov/re-powering)

This web site provides a variety of resources related to the use of renewable energy approaches throughout a remediation project and integrating these approaches into the planning of the project. Institutional controls are discussed that may limit application of renewable energy projects including zoning, fish advisories, restrictive covenants, easements and deed notices.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Clean Fuel & Emission Technologies for Site Cleanup.* (2010)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers the use of clean fuels and emission control technologies during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Diesel Emissions Quantifier.* (2015)
(http://www2.epa.gov/cleandiesel/diesel-emissions-quantifier-deq)

This interactive tool can be used to evaluate clean diesel projects by estimating emission reductions, cost effectiveness, and health benefits associated with emission reductions.

Case Studies

Federal Contaminated Sites Action Plan (FCSAP). *Wind-Powered Groundwater Sparging at Farnworth Lake Case Study*. (2014)
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#farnworth)

Remediation options at this site were limited due to the remoteness of the site: any equipment that could not be brought from nearby Churchill would be very expensive to transport. As well, because site was off the electrical grid, any remediation equipment would also have to be powered on site. Finally, the harsh subarctic weather conditions further limited the remediation options for the site. The solution for this site was a groundwater remedial system that used windmill-driven turbines to power a compressor to supply air for a groundwater sparging system that would remediate the petroleum hydrocarbons in the groundwater.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Air Emissions)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA web site provides a table of several sustainable remediation case studies and indicates the best management practices used in them. The table can be used to select profiles that highlight techniques for air emission reduction. Included in the descriptions are innovative technologies and novel field methods.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Energy Efficiency)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates the best management practices used in them. The table can be used to select profiles that highlight techniques related to energy efficiency. Included in the descriptions are innovative technologies and novel field methods.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Energy - Renewable)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates the best management practices used in them, including renewable energy. Included in the descriptions are innovative technologies and novel field methods.

U.S. Environmental Protection Agency (U.S. EPA). *Renewable Energy use on Contaminated Sites - Fact Sheets and Success Stories*. (no date)
(http://www2.epa.gov/re-powering/re-powering-your-community#factsheets_success)

These fact sheets highlight renewable energy installations on current and formerly contaminated lands, landfills, and mine sites.

Evaluate Sustainability Options for the Project - References (Section 5.1.5)

(Note: This section provides guidance and references specific to the evaluation of sustainability options for the project as a whole. Section 7.1.1 provides information and references related specifically to remediation technology sustainability evaluation.)

General Guidance

Bleichera. A and M. Grossa. *Sustainability assessment and the revitalization of contaminated sites: operationalizing sustainable development for local problems.* International Journal of Sustainable Development & World Ecology. Volume 17, Issue 1,. (2010)
(http://www.tandfonline.com/doi/abs/10.1080/13504500903488263) (fee applies)

This paper describes how to develop sustainability indicators that can support users in establishing case-specific criteria for sustainable site remediation. The paper describes the different steps in the indicator development process and discusses areas that need to be improved in order to derive answers that reach beyond the field of contaminated site management.

California Environmental Protection Agency. *Interim Advisory for Green Remediation.* State of California: Department of Toxic Substances Control. (2009)
(http://www.dtsc.ca.gov/OMF/upload/GRT_Draft_-Advisory_-20091217_ac1.pdf)

This procedural document discusses the concepts of sustainability and life-cycle management and incorporates them into all stages of the cleanup project. It also introduces the Green Remediation Evaluation Matrix (GREM) which highlights qualitative comparisons of treatment alternatives.

Illinois Environmental Protection Agency. *Greener Cleanups: How to Maximize the Environmental Benefits of Site Remediation*. State of Illinois: Environmental Protection Agency, Bureau of Land. (2008)
(http://www.epa.state.il.us/land/greener-cleanups/matrix.pdf)

This document presents a matrix for selecting sustainable practices for site assessment, planning and design, and cleanup. The matrix allows the user to analyze actions taken for site remediation by cost, schedule and technical complexity and shows how they benefit the environment. The article separates the environmental benefits into 4 different categories: air, water, land and energy.

International Journal of Sustainable Development & World Ecology. *Sustainability assessment and the revitalization of contaminated sites: operationalizing sustainable development for local problems.* International Journal of Sustainable Development & World Ecology. Volume 17, Issue 1. (2010)
(http://www.tandfonline.com/doi/abs/10.1080/13504500903488263) (fee applies)

The paper describes how to develop sustainability indicators that can support users in establishing case-specific criteria for sustainable site remediation. The paper describes the different steps in the indicator development process and discusses areas that need to be improved in order to derive answers that reach beyond the field of contaminated site management.

Minnesota Pollution Control Agency. *Toolkit for Greener Practices: Decision Tree*. (2011)
(http://www.pca.state.mn.us/index.php?option=com_k2&view=item&id=2274)

This Decision Tree is intended to help determine options for more sustainable practices that are appropriate to a site. The fifteen options listed in the Decision Tree relate to business operations, site development and site cleanup. They are grouped according to three scenarios: Cleanup Remedy Selection; Business Practices; Development and Renovation.

P.B. Butler et al. *SURF Metrics for Integrating Sustainability Evaluations Into Remediation Projects.* Remediation, 21(3), pp. 81-87. (2011)
(http://www.sustainableremediation.org/library/guidance-tools-and-other-resources/Metrics-20290_ftp.pdf)

This report summarizes a series of metrics that can be used to evaluate the sustainability of various aspects of a contaminated sites remediation project. Metrics are divided into the typical project stages: investigation, remedy selection, remedial design and construction and operation and maintenance.

P.J. Favara et al. *SURF Guidance for Performing Footprint Analyses and Life-Cycle Assessments for the Remediation Industry.* Remediation, 21(3), pp. 39-79. (2011)
(http://www.sustainableremediation.org/library/guidance-tools-and-other-resources/Footprint-LCA-20289_ftp.pdf)

This paper considers the limitations of current life cycle analysis approaches. (no standardization across professions, metrics, scope and boundaries, lack definition etc.) and provides a standardized nine-step process for measuring the outputs of remediation activities. While it focuses on the ISO standards for LCA and ecological and human health risk assessment, it may be applied to both the social and economic issues. The paper also provides two case studies and tips for implementation.

Regeneration of European Sites in Cities and Urban Environments (Rescue) *Best practice guidance for sustainable brownfield regeneration.* (2005)
(http://www.eugris.info/DisplayResource.asp?ResourceID=5442&t=Manual: Best practice guidance for sustainable brownfield regeneration)

This Manual describes the RESCUE Sustainability Assessment Tool (RESCUE-SAT) which provides a methodology for a site specific evaluation of intended brownfield projects in terms of sustainability. The manual covers: (1) Administrative Tools and Incentives for sustainable brownfield regeneration;. (2) End-user tools for sustainable brownfield regeneration; (3) A Virtual Training Centre which provides web based training resources for sustainable brownfield regeneration.

Ryan, J. et al. *Sustainable Remediation Panel – Screening and Selecting Green and Sustainable Best Management Practices.* Remediation. (2011)
(http://onlinelibrary.wiley.com/) (fee applies)

This journal article describes the process taken by several remediation professionals from different firms (AECOM, CH2MHILL, and SCS Engineers) to rank and organize BMPs for their respective remediation projects.

Sustainable Remediation Forum (SuRF) Australia. *A Framework for Assessing the Sustainability of Soil and Groundwater Remediation. (*2011)
(https://landandgroundwater.softlinkhosting.com.au/liberty3/libraryHome.do)

This framework builds on the SuRF UK Framework for Incorporating Sustainable Development Criteria in Soil and Groundwater Remediation and applies it to the Australian context. The document describes sustainability assessment approaches that can be used during the two main stages where sustainable remediation decision-making is applied: 1) project/plan design stage and 2) point of remediation selection and implementation.

Sustainable Remediation Forum (SuRF) U.S. *SURF Metrics Toolbox.* (2011)
(http://www.sustainableremediation.org/library/guidance-tools-and-other-resources/metrics-toolbox/)

This toolbox provides a compilation of information on evaluation tools, metrics, implementation guidance, challenges and benefits for a range of parameters associated with the following site remediation steps:

- Remedial Design
- Remedial Investigation
- Remedy Selection
- Remedial Construction

Sustainable Remediation Forum (SuRF) *U.S. SURF Guidance for Performing Footprint Analyses and LCAs in the Remediation Industry*. Remediation. (2011)
http://static1.1.sqspcdn.com/static/f/361803/12807992/1308604751560/Footprint-LCA-20289_ftp.pdf?token=ELjDBw6BBjilmilOck3mHQ%2Bkiyo%3D

This guide presents a nine-step process for conducting and documenting a footprint analysis and life-cycle assessment (LCA) for remediation projects.

Sustainable Remediation Forum (SuRF) UK. *SuRF UK Sustainable Management Practices spreadsheet.* (2014)
(http://www.claire.co.uk/index.php?option=com_phocadownload&view=file&id=403:surf-uk-smps&Itemid=230)

This spreadsheet has been produced in combination with the document "Sustainable management practices for management of land contamination" (CL:AIRE, 2014). This spreadsheet can be used to identify practices that, individually or collectively, may lead to project "sustainability gains".

Sustainable Remediation Forum (SuRF) UK. *SuRF UK-URS Tier 1 Sustainability Assessment.* (no date)
(http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=405:tier-1-sustainability-assessment-for-surf-uk-urs-final&id=16:surf-uk-bulletins&Itemid=230)

This Tier 1 Sustainability Assessment spreadsheet is based on the SuRF-UK "briefcase" and should enable assessments to be carried out systematically according to SuRF-UK's guidance. The process is divided into three categories: 1. Preparation - describing the project, the purpose of the assessment, the stakeholders, the constraints and the reporting/dialogue plan; 2. Definition - defining the objectives, boundaries, scope, methodology and uncertainties; 3. Execution - tables to aid the execution of the assessment, including the SuRF-UK assessment criteria"

United Nations Environment Program. *Guidelines for Social Life-Cycle Assessment of Products.* (2009)
(http://www.unep.fr/shared/publications/pdf/DTIx1164xPA-guidelines_sLCA.pdf)

These guidelines provide a framework and best-practices for assessing the social and socio-economic impacts of product life cycles

U.S. ENVIRONMENTAL PROTECTION AGENCY (U.S. EPA). *Framework for Responsible Environmental Decision-Making (FRED): Using Life Cycle Assessment to Evaluate Preferability of Products.*(2000)
(http://www.gdrc.org/decision/fred.pdf)

The Framework for Responsible Environmental Decision-Making (FRED) demonstrates how the life-cycle concept can be used to quantify competing products' environmental performance so that this information may be integrated with considerations of total ownership cost and technical performance. Specifically, this report describes how life cycle assessment (referred to as the "FRED LCA approach") can be applied to determine and compare the environmental and human health impacts of competing products.

U.S. Environmental Protection Agency (U.S. EPA). *Spreadsheets for Environmental Footprint Analysis (SEFA).* (no date)
(http://www.cluin.org/greenremediation/methodology/index.cfm)

These spreadsheets are intended to be used along with the EPA methodology for providing quantitative information about the footprint reductions gained by applying EPA's green remediation best management practices (BMPs).

U.S. Navy, Naval Facilities Engineering Command (NAVFAC). *SiteWise™ GSR Tool.* (no date)
(https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/gsr.html#resources)

SiteWise is an Excel-based quantitative, calculation tool jointly developed by Battelle, US Navy, and USACE. It is designed to determine footprints of environmental restoration actions in terms of selected metrics such as greenhouse gas (GHG) emissions, energy consumption, criteria air pollutant emissions, water consumption, and worker safety.

Case Studies

Tajarn, J.A et al. *Small Scale In-Situ Bioremediation of Diesel Contaminated Soil – Screening Life-cycle Analysis (LCA) of Environmental Performance*, in International Conference on Natural Sciences and Technologies for Waste and Wastewater Treatment, Remediation, Emissions Related to Climate, Environmental and Economic Effects. (2010)
(http://swepub.kb.se/bib/swepub:oai:DiVA.org:miun-12255?tab2=abs&language=en)

This paper provides a LCA for the use of enhanced bioremediation of diesel contaminants in soil using whey, a byproduct from cheese production. Using an actual diesel contamination site as a case study, a screening life cycle assessment model was used. The goal of the study was to investigate the environmental performance of the whey method, and compare it with excavation and composting. Results from the screening life cycle assessment indicate a good environmental performance of the whey method and concluded that the whey on-site treatment could be an interesting alternative for bioremediation especially at sites that would not otherwise be treated, due to small size or remote location.

Other Sustainable Site Management Considerations - References (Section 5.1.6)

General Guidance

Interagency Technology and Regulatory Council (ITRC). *Planning and Promoting Ecological Land Reuse of Remediated Sites. Technical and Regulatory Guidance. (*2006)
(www.itrcweb.org/Guidance/GetDocument?documentID=30)

This document highlights the benefits and constraints of ecological land reuse. Provides decision making criteria as well as cost benefit considerations. Applies sustainability to outcomes with coverage of community stakeholders as well as economic and environmental benefits.

U.S. Environmental Protection Agency (U.S. EPA). *The Incorporation of an Ecosystem Services Assessment into the Remediation of Contaminated Sites*, Sarah Slack, National Network for Environmental Management Studies Fellow, University of Connecticut. (2010)
(https://clu-in.org/download/techdrct/sarah-slack-ecosystem-services.pdf)

Based on literature research and personal communications, this report presents background information related to ecosystem protection and the steps that can be taken to mitigate or avoid impacts to ecosystems throughout the remediation process. The report outlines replicable practices that remedial project managers can utilize to mitigate adverse impacts on an ecosystem. This report also describes the current state of data collection methods and issues pertinent to the ecosystem service assessment process, with the ultimate aim of fostering production of a replicable methodology that can lead to greener cleanups.

U.S. Environmental Protection Agency (U.S. EPA). *Climate Change Adaptation Technical Fact Sheet: Contaminated Sediment Remedies. (*2015)
(http://lacf.ca/sites/default/files/documents/portfolio/Todd_Leila_042013_MLA-opt.pdf)

This fact sheet examines how climate change may impact the US EPA's existing processes for planning and implementing contaminated sediment cleanup projects. It shows how climate change vulnerability analyses and adaptation planning may be integrated throughout the contaminated site management process. A site-specific strategy for considering climate change impacts and potential adaptation measures is encouraged due to wide variation in the location and hydrogeologic characteristics of contaminated sites, the nature of remedial actions at those sites, and local or regional climate and weather regimes.

U.S. Environmental Protection Agency (U.S. EPA). *Superfund Climate Change Adaptation - Webpage.* (no date)
(http://www2.epa.gov/superfund/superfund-climate-change-adaptation)

This Web page shares information about approaches for adapting to climate change during the cleanup contaminated sites.

Case Studies

Federal Contaminated Sites Action Plan (FCSAP). *Colomac Mine Remediation Project Case Study*. (no date)
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#colomac)

This case study describes the use of locally harvested materials, soil bioengineering techniques and natural processes, which have lead to sustainable revegetation of river and lake shorelines after contamination from the closed Colomac gold mine.

Federal Contaminated Sites Action Plan (FCSAP). *Colwood Refuelling Facility Engineered Wetlands Case Study*. (no date)
(https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#colwood)

Engineered wetlands were used at this military refueling facility as a low cost solution to manage the contamination at the site. Once the remediation was completed, the remaining wetlands were a visually pleasing habitat for waterfowl and vegetation. This study shows how many of the obstacles that make revegetation especially challenging in the north were overcome. Specifically, the remote location drives up the costs for both labour and transporting materials; and the establishment of a heavily seeded initial cover in a subarctic climate could easily out-compete native species and hinder natural succession of vegetation at the site.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Land and Ecosystem)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates the best management practices used in them. The table can be used to select profiles that highlight techniques for land-use and ecosystem protection. Included in the descriptions are innovative technologies and novel field methods.

6 Initial / Detailed Testing Program and Site Assessment (DMF Steps 3 to 6)

6.1 Sustainable Best Management Practices

Initial / Detailed Testing Program - Site Assessment (FCSAP Steps 3 to 6) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
6.1.1 Sustainable Site Assessment (References) Plan and implement sustainable site assessment methods that reduce energy and waste generation, where possible, while still providing the necessary due diligence. Examples include:	X	X
• Use on-site analytical techniques to avoid long-distance transportation of samples to laboratories,	X	X
• Use passive analytical devices that avoid the need for digging wells and bore holes,	X	X
• If wells / boreholes are required, use drilling / digging techniques that reduce waste generation, such as low flow purge techniques for groundwater sampling,	X	X
• If sampling is required, develop a strategic sampling plan and use statistical methods to avoid over sampling of the site,		X
• Use telemetry or remote data collection.		X
6.1.2 Sustainable Contracting Methods (References) Develop and use sustainable contracting clauses as outlined in the Environmental Procedures in Section 01-35-43 of the Public Works and Government Services Canada's National Master Specification.	X	X

* Notes
Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

6.2 References

Sustainable Site Assessment and Monitoring Activities - References (Section 6.1.1 & 9.1.1)

General Guidance

Federation of Canadian Municipalities (FCM). *FCM Sustainable Site Assessments Webpage*. . (no date) (http://www.fcm.ca/home/programs/green-municipal-fund/get-started-today/revitalize-your-brownfields/sustainable-remediation/sustainable-site-assessments.htm)

This web page presents information and examples of various sustainable site assessment techniques.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Site Investigation*. (2009) (https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This fact sheet covers non-intrusive sampling techniques, using green-certified laboratories and minimizing in office use of non-'green' products

Sustainable Contracting Methods - References (Section 6.1.2, 7.1.4 & 9.1.2)

General Guidance

Public Works and Government Services Canada (PWGSC). *PWGSC Green Procurement Policy*. (2006) (https://www.tbs-sct.gc.ca/pol/doc-eng.aspx?id=32573)

The objective of this document is to advance the protection of the environment and support sustainable development by integrating environmental performance considerations into the procurement decision-making process. Departmental Deputies are required to ensure that the green procurement objectives outlined in the policy are realized while maintaining compliance with all legislative, regulatory and policy obligations.

Public Works and Government Services Canada. *Environmental Procedures in Section 01-35-43 of the Public Works and Government Services Canada's National Master Specification*. (no date) (Not publically available, copies are available from regional PWGSC procurement officers.)

This document includes a series of specifications related to environmental protection and sustainable remediation. The intent is that these specification be added to remediation contracts to provide bidders with clear requirements related to protecting the environment and performing their work in a sustainable manner.

Case Study

Sustainable Remediation Forum (SuRF) UK. *SURF UK Bulletin Case Study -Upper Heyford - Remediation Options Appraisal*. (2013) (http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=366:surf-case-study-2&id=16:surf-uk-bulletins&Itemid=230)

The case study involved the decommissioning of the petroleum dispensing system at a former cold war military airbase. A remediation options and sustainability analysis was undertaken as part of a competitive tendering process. The objective of this analysis was to act as a commercial tool at tender stage to show understanding of the issues and inform the decision making process. It was also used to demonstrate to regulators that the selected remedial option was the most sustainable.

7 Remediation / Risk Management Strategy Development (DMF Step 7)

7.1 Sustainable Best Management Practices

Develop Remediation / Risk Management Strategy (FCSAP Steps 7) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
7.1.1 Sustainable Remediation / Risk Management Selection (References) *(Note: This section provides guidance and references specific to remediation technology sustainability evaluation. Section 5.1.5 provides information and references related to the evaluation of sustainability options for the project as a whole.)* Consider sustainability when selecting remediation and / or risk management methods:	X	X
• Consider risk management (as opposed to remediation) approaches where appropriate land-use restrictions and human health and environmental protection can be made.	X	X
• Where risk management approaches are not possible, consider the use of in-situ remediation techniques and those that destroy contaminants.	X	X
• Use a qualitative or semi-qualitative (i.e., PSPC's Sustainable Development (SD) Analysis Tool) approach to evaluate the sustainability of viable remediation or risk management options for the site.	X	X
• Use a quantitative (i.e., life-cycle analysis) approach to evaluate the sustainability of viable remediation or risk management options for the site.		X
7.1.2 Update Sustainability Plan (References) Update and refine the preliminary sustainability plan developed in FCSAP Step 2 (as described in Section 5.1.1)	X	X
7.1.3 Sustainable Remediation Demonstration (References) Look for opportunities to demonstrate the feasibility of incorporating sustainable remediation activities.		X
7.1.4 Sustainable Contracting Methods (References) Develop and use sustainable contracting clauses as outlined in the Environmental Procedures in Section 01-35-43 of the Public Works and Government Services Canada's National Master Specification.	X	X

* Notes
Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

7.2 References

Sustainable Remediation / Risk Management Selection - References (Section 7.1.1)

General Guidance

(Note: This section provides guidance and references specific to remediation technology sustainability evaluation. Section 5.1.5 provides information and references related specifically to the evaluation of sustainability options for the project as a whole.)

Australian Government Department of Defence. *Guidelines for consideration of sustainability in remediation of contaminated sites*. (2010)
(http://www.defence.gov.au/estatemanagement/governance/policy/environment/contamination/docs/sustainabilityremediationguidelines.pdf)

This guideline is intended for use by project development and environmental managers and their consultants who are responsible for making decisions regarding works and the remediation of Defence sites. It outlines the Defence framework for implementation of sustainability principles in contamination management including identification of the key property life cycle points at which to consider sustainability, and a framework for the consideration of sustainability in the broader contamination management options assessment process.

A broad remediation options assessment framework is presented that outlines the key requirements for contamination management to be met prior to evaluation of the sustainability of a remediation approach from an environmental, social and economic perspective. Three Defence case studies are presented that have evaluated remediation options, taking into consideration the environmental, social and economic benefits and dis-benefits that may ensue. The level of assessment required at this stage and the complexity of evaluation methods applied have to be commensurate with the size and nature of the project.

Air Force Civil Engineer Center (AFCEC). *Sustainable Remediation Tool (SRT)*. (no date)
(No longer available from web site but available by e-mailing AFCEC (afcec.czte.rss@us.af.mil))

AFCEC and its partners have developed the Sustainable Remediation Tool (SRT) to serve two general purposes: 1) planning for future implementation of remediation technologies at a particular site, as well as 2) a means to evaluate optimization of remediation technology systems already in place or to compare remediation approaches based on sustainability metrics.

California Environmental Protection Agency. *Interim Advisory for Green Remediation*. State of California: Department of Toxic Substances Control. (2009)
(http://www.dtsc.ca.gov/OMF/upload/GRT_Draft_-Advisory_-20091217_ac1.pdf)

This procedural document discusses the concepts of sustainability and life-cycle management and incorporates them into all stages of the cleanup project. It also introduces the Green Remediation Evaluation Matrix (GREM) which performs qualitative comparisons of treatment alternatives.

California Environmental Protection Agency. *Leaking UST Footprint Calculator. (no* date)
(http://ustcalc.org/)

This calculator estimates and compares the greenhouse gas emissions for the five most common remediation technologies used at contaminated underground storage tank sites in California.

Federation of Canadian Municipalities (FCM). *FCM Sustainable Remediation and Risk Management Options Web page*. (no date)

(http://www.fcm.ca/home/programs/green-municipal-fund/get-started-today/revitalize-your-brownfields/sustainable-remediation/sustainable-remediation-and-risk-management-options.htm)

This web page presents information and examples of various sustainable site remediation and risk assessment techniques.

Harre et al. *Quantifying Life Cycle Environmental Footprints of Soil and Groundwater Remedies.* (2013) (http://www.serdp.org/content/download/22250/229137/file/ER-201127-FR.pdf)

This article provides a comparison of various green and sustainable remediation tools, such as SiteWise and SRT and benchmarks them against SimaPro LCA software

Illinios Environmental Protection Agency. *Greener Cleanups: How to Maximize the Environmental Benefits of Site Remediation.* State of Illinois: Environmental Protection Agency, Bureau of Land. (2008) (http://www.epa.state.il.us/land/greener-cleanups/matrix.pdf)

This document presents a matrix for selecting sustainable practices for site assessment, planning and design, and cleanup. The matrix allows the user to analyze actions taken for site remediation by cost, schedule and technical complexity and shows how they benefit the environment. The article separates the environmental benefits into 4 different categories: air, water, land and energy.

Interagency Technology and Regulatory Council (ITRC). *Life Cycle Cost Analysis - First in a Series of Remediation Process Optimization Advanced Topics.* (2006) (www.itrcweb.org/GuidanceDocuments/RPO-2.pdf)

This report provides information on the basic concepts of Life-Cycle Cost Analysis and its potential application to site remediation projects. Two hypothetical sites have been created and are used to "walk" the practitioner through the life-cycle analysis process as examples. Each example has an existing remedial operation that is not achieving the site's exit strategy on schedule or budget. The examples present the site's remedial objectives, the current remediation status, the life-cycle cost of the current operation, alternative remediation processes for both cost and schedule, and then compares the life-cycle cost of all the options. The benefits and returns are evaluated and summarized for each site. The document provides an example calculation of a current project costs compared to an alternative method. It requires a single cost figure for each alternative, which should last the duration of the project.

Minnesota Pollution Control Agency. *Toolkit for Greener Practices: Decision Tree.* (2011) (http://www.pca.state.mn.us/index.php?option=com_k2&view=item&id=2274)

This Decision Tree is intended to help determine options for more sustainable practices that are appropriate to a site. The fifteen options listed in the Decision Tree relate to business operations, site development and site cleanup. They are grouped according to three scenarios: Cleanup Remedy Selection; Business Practices; Development and Renovation.

P.B. Butler et al. *SURF Metrics for Integrating Sustainability Evaluations Into Remediation Projects.* Remediation, 21(3), pp. 81-87. (2011) (http://www.sustainableremediation.org/library/guidance-tools-and-other-resources/Metrics-20290_ftp.pdf)

This report summarizes a series of metrics that can be used to evaluate the sustainability of various aspects of a contaminated sites remediation project. Metrics are divided into the typical project stages: investigation, remedy selection, remedial design and construction and operation and maintenance.

Strategic Environmental Research and Development Program (SERDP). *Quantifying Life Cycle Environmental Footprints of Soil and Groundwater Remedies.* (2011) (https://www.serdp-estcp.org/Program-Areas/Environmental-Restoration/Contaminated-Groundwater/Monitoring/ER-201127/ER-201127/%28language%29/eng-US)

This report describes a project to demonstrate and validate two currently used, publicly available Department of Defense (DoD) green and sustainable remediation (GSR) spreadsheet tools (SiteWise™ and SRT™) and benchmark these tools against an industry accepted Life-Cycle Assessment (LCA) software package (SimaPro®).

Sustainable Remediation Forum (SuRF) UK. *SuRF UK-URS Tier 1 Sustainability Assessment*. (no date) (http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=405:tier-1-sustainability-assessment-for-surf-uk-urs-final&id=16:surf-uk-bulletins&Itemid=230)

This Tier 1 Sustainability Assessment spreadsheet is based on the SuRF-UK "briefcase" and should enable assessments to be carried out systematically according to SuRF-UK's guidance. The process is divided into three categories: 1. Preparation - describing the project, the purpose of the assessment, the stakeholders, the constraints and the reporting/dialogue plan; 2. Definition - defining the objectives, boundaries, scope, methodology and uncertainties; 3. Execution - tables to aid the execution of the assessment, including the SuRF-UK assessment criteria"

Case Studies

Australian Government Department of Defence. *Guidelines for consideration of sustainability in remediation of contaminated sites*. (2010) (http://www.defence.gov.au/estatemanagement/governance/policy/environment/contamination/docs/sustainabilityremediationguidelines.pdf)

This guideline is intended for use by project development and environmental managers and their consultants who are responsible for making decisions regarding works and the remediation of Defence sites. It outlines the Defence framework for implementation of sustainability principles in contamination management including identification of the key property life cycle points at which to consider sustainability, and a framework for the consideration of sustainability in the broader contamination management options assessment process.

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Bayer, P. and Finkel, M. *Life Cycle Assessment of Active and Passive Groundwater Remediation Technologies. Journal of Contaminant Hydrology*. (2006) (http://www.researchgate.net/profile/Peter_Bayer3/publication/7392008_Life_Cycle_Assessment_of_Active_and_Passive_Groundwater_Remediation_Technologies/links/00b495204d17ac2d20000000.pdf)

This article presents a case study where the use of a permeable reactive barrier and a pump and treat technology are compared at manufactured gas plant site in Germany. A life cycle assessment is used to compare these two technologies.

Federal Contaminated Sites Action Plan (FCSAP). *Brevoort Island Remedial Options Analysis Case Study*. (no date) (https://www.canada.ca/en/environment-climate-change/services/federal-contaminated-sites/making-progress.html#brevoort)

A pipe failure at a Department of National Defence (DND) Long Range Radar Facility on Brevoort Island, located just off the coast of Baffin Island, Nunavut, led to the accidental release of about 150 000 litres of Jet A-1 aviation turbine fuel. This work involved performing a remedial options analysis that incorporated sustainability elements, including "green" remediation and reuse of waste materials. The analysis used a weighted scoring system based on the principles of multi-criteria decision analysis, which allowed for weighting of sustainability indicators, such as social and economic impacts, as part of an overall life cycle approach.

Federation of Canadian Municipalities (FCM) Case Studies. *Remediation and Redevelopment of the former WC Wood Company Site I Facility, City of Guelph*. (2012)

(http://www.fcm.ca/home/programs/green-municipal-fund/funded-initiatives.htm?lang=en&project=9e45e11d-d16e-e211-820e-005056bc2614&srch=brownfield)

This case study describes the use of a risk management approach at a brownfield site in Guelph, Ontario. The Remedial Action Plan for the site involves a combination of site-specific risk-based standards, active on-site remediation, and the implementation of risk management measures. Soil management is an important component of the plan, allowing certain soils to be reused on-site rather than transported and dumped.

Higgins, M.R. and T.M. Olson. *Life-Cycle Case Study Comparison of Permeable Reactive Barrier versus Pump-and-Treat Remediation in Environmental Science and Technology*. (2009) (http://pubs.acs.org/doi/abs/10.1021/es9015537)

In this article permeable reactive barrier (PRB) technology is compared with a conventional pump-and-treat system using a life-cycle assessment (LCA). This assessment is used to determine if the greater material production requirements to install PRBs may offset the expected reductions in operational phase impacts. The life-cycle environmental impacts of a zerovalent iron (ZVI) containing PRB with a funnel and gate configuration and pump and treat are compared in a case study. This study showed that, even at conservatively low estimates of longevity, the PRB offers significant environmental advantages in impact categories of human health and ozone depletion. Suggested PRB design innovations to reduce environmental impacts include the development of alternative reactive media and construction methods.

Higgins, M.R. and T.M. Olson. *Life-Cycle Case Study Comparison of Permeable Reactive Barrier versus Pump-and-Treat Remediation in Environmental Science and Technology*. (2009) (http://pubs.acs.org/doi/abs/10.1021/es9015537)

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Monica R. Higgins and Terese M. Olson. *Life-Cycle Case Study Comparison of Permeable Reactive Barrier versus Pump-and-Treat Remediation in Environmental Science and Technology*. (2009) (http://pubs.acs.org/doi/abs/10.1021/es9015537)

In this article permeable reactive barrier (PRB) technology is compared with a conventional pump-and-treat system using a life-cycle assessment (LCA). This assessment is used to determine if the greater material production requirements to install PRBs may offset the expected reductions in operational phase impacts. The life-cycle environmental impacts of a zerovalent iron (ZVI) containing PRB with a funnel and gate configuration and pump and treat are compared in a case study. This study showed that, even at conservatively low estimates of longevity, the PRB offers significant environmental advantages in impact categories of human health and ozone depletion. Suggested PRB design innovations to reduce environmental impacts include the development of alternative reactive media and construction methods.

Sustainable Remediation Forum (SuRF) UK. *SURF UK Bulletin - Helpston Contaminated Land Project*. (2013) (http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=367:surf-case-study-3&id=16:surf-uk-bulletins&Itemid=230)

This case study examines the use of a sustainability options analysis at two former waste disposal sites with significant groundwater contamination. This is a retrospective review of a previous remediation options analysis, to examine how it would have differed had the SuRF-UK framework been used and also explores the benefits SuRF-UK framework can bring.

Sustainable Remediation Forum (SuRF) UK. *SURF UK Bulletin -Upper Heyford - Remediation Options Appraisal*. (2013)
http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=366:surf-case-study-2&id=16:surf-uk-bulletins&Itemid=230

The case study involved the decommissioning of the petroleum dispensing system at a former cold war military airbase. A remediation options and sustainability analysis was undertaken as part of a competitive tendering process. The objective of this analysis was to act as a commercial tool at tender stage to show understanding of the issues and inform the decision making process. It was also used to demonstrate to regulators that the selected remedial option was the most sustainable.

Sustainable Remediation Forum (SuRF) UK. *SuRF UK Bulletin - Sustainability Assessment: Shell Terminal Facility, Madeira*. (2013)
(http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=365:surf-case-study-1&id=16:surf-uk-bulletins&Itemid=230)

A sustainable remediation assessment was applied in this project. This assessment compared ex-situ thermal desorption process to in-situ enhanced bioremediation. The bioremediation option was chosen based on the following sustainability benefits:

- A reduction in CO2 emissions due to less intensive energy use;
- A reduction in costs;
- A reduction in fuel use;
- A reduction in neighbourhood disturbance caused by noise, which would have arisen from the operation of the thermal desorption plant; and
- Potential for local employment.

Tajam, J.A. et al. *Small Scale In-Situ Bioremediation of Diesel Contaminated Soil – Screening LCA of Environmental Performance, in International Conference on Natural Sciences and Technologies for Waste and Wastewater Treatment, Remediation, Emissions Related to Climate, Environmental and Economic Effects*. (2010)
(http://swepub.kb.se/bib/swepub:oai:DiVA.org:miun-12255?tab2=abs&language=en)

This paper provides a LCA for the use of enhanced bioremediation of diesel contaminants in soil using whey, a byproduct from cheese production. Using an actual diesel contamination site as a case study, a screening life cycle assessment model was used. The goal of the study was to investigate the environmental performance of the whey method, and compare it with excavation and composting. Results from the screening life cycle assessment indicate a good environmental performance of the whey method and concluded that the whey on-site treatment could be an interesting alternative for bioremediation especially at sites that would not otherwise be treated, due to small size or remote location.

Sustainable Remediation Demonstration - References (Section 7.1.3)

General Guidance

UK Contaminated Land: Applications in Real Environments (CL:AIRE). *CL:AIRE - Technology Demonstration Projects Web Page*. (no date)
(https://www.claire.co.uk/cl-aire-projects)

One of CL:AIRE's core objectives is to demonstrate the application of technologies which may offer improved site investigation techniques, monitoring or remediation solutions. As outlined in this web page, in order to meet this objective, CL:AIRE has developed a process in which demonstration projects are submitted, evaluated by a team of independent experts (CL:AIRE's Technology and Research Group), and – if approved – monitored and reported so that the industry as a whole can benefit from the results.

8 Remediation / Risk Management Strategy Implementation (FCSAP Steps 8)

8.1 Sustainable Best Management Practices

Implement Remediation / Risk Management Strategy (FCSAP Steps 8) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
8.1.1 Sustainability Plan Implementation (References) Implement the sustainability plan developed and identified in Step 7 *(as described in Section 7.1.2)*	X	X
8.1.2 Sustainable Remediation / Risk Management Implementation Implement the sustainable remediation / risk management methods selected in Step 7 and as part of the remedial action plan. Sustainable methods related to specific remediation techniques include:	X	X
8.1.3 Soil Excavation *(References)*		
• Reduce excavation and off-site disposal, where possible,	X	X
• Consider use of on-site treatment rather than off-site treatment of soils		
• Avoid unnecessary extraction of soil by performing proper delineation of contamination		
• Sequence work to minimize double-handling of materials.		X
• Make beneficial reuse of excavated soils on-site, where possible,	X	X
• Use renewable energy sources or clean fuels to power equipment and vehicles		
• If transport of materials is required, transport to a location as close as possible to the site		
• Segregate and recycle or reuse waste, demolition materials (e.g., concrete, rebar),	X	X
• Reduce water use	X	X
• When additional material is required for fill, select local material that is comprised of post-consumer recycled materials, such as crushed concrete,	X	X
8.1.4 In-situ Remediation Optimization *(References)*		
• Optimize systems to reduce reagent volumes, extraction rates and number of injection wells		
• Use existing wells as injection points		
• Use direct push drilling methods		
• Use renewable energy sources to power injection pumps		

Implement Remediation / Risk Management Strategy (FCSAP Steps 8) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
• Recirculate extracted groundwater for reagent blending		
• Use reagents that are waste byproducts from other processes		
8.1.5 Groundwater Pump and Treat Optimization *(References)*		
• Optimize systems to reduce number of extraction wells and reagent use		
• Reuse extracted water		
• Use renewable energy sources to power extraction pumps		
8.1.6 Sustainable Contracting Methods (References) Implement sustainable contracting clauses as outlined in the Environmental Procedures in Section 01-35-43 of the Public Works and Government Services Canada's National Master Specification.	X	X

* Notes
Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

8.2 References

Soil Excavation - References (Section 8.1.3)

General Guidance

Contaminated Land: Applications in the Real Environments (CL:AIRE). *Use of the Definition of Waste: Development Industry – Code of Practice in London & the South East*. (2013)
(https://www.claire.co.uk/projects-and-initiatives/dow-cop)

This code of practice details a process for the re-use of materials on site or their movement between sites with a significantly reduced UK regulatory burden. It also creates the conditions to support the establishment and operation of fixed soil treatment facilities, which have a key role to play in the future of sustainable materials management. The process covers the reuse of both contaminated and uncontaminated materials on the site of production, and between sites within defined "Cluster" projects.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Excavation and Surface Restoration*. (2008)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to excavation and surface restoration.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Materials and Waste Management*. (2013)
(https://clu-in.org/greenremediation/)

These US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to material and waste reduction at management during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Mining Sites*. (2012)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches at mine site remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Sites with Leaking Underground Storage Tank Systems*. (2011)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to leaking underground storage tank systems.

U.S. Environmental Protection Agency (U.S. EPA). *Recycled Content (ReCon) Tool*. (2010)
(http://www3.epa.gov/epawaste/conserve/tools/warm/ReCon_home.html)

The ReCon Tool calculates GHG emissions and energy consumption related to purchasing and/or manufacturing activities using analyses of baseline and alternative recycled-content

scenarios. Specifically, the tool can be used to calculate the tons of material reduced through purchase or use of items with recycled content

U.S. Environmental Protection Agency (U.S. EPA). *Waste Reduction Model (WARM)*. (2012) (https://www.epa.gov/warm)

The WARM model calculates GHG emissions of baseline and alternative waste management practices such as, source reduction, recycling, combustion, composting, and landfilling. The model calculates GHG emissions based on typical and alternative waste management strategies and includes 46 different material types as well as a variety of output units including MTCE, MTCO2E, and million BTU.

Case Studies

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Materials and Waste)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates the best management practices used in them. The table can be used to select profiles that highlight techniques for material and waste reduction. Included in the descriptions are innovative technologies and novel field methods.

In-situ Remediation Optimization - References (Section 8.1.4)

General Guidance

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Bioremediation*. (2010)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to bioremediation.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Implementing In Situ Thermal Technologies*. (2012)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to in-situ thermal remediation.

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Soil Vapor Extraction and Air Sparging*. (2010)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to the use of soil vapour extraction and air sparging.

Case Studies

Bayer, P. and M. Finkel. *Life Cycle Assessment of Active and Passive Groundwater Remediation Technologies. Journal of Contaminant Hydrology*. (2006) (http://www.researchgate.net/profile/Peter_Bayer3/publication/7392008_Life_Cycle_Assessment_of_Active_and_Passive_Groundwater_Remediation_Technologies/links/00b495204d17ac2d20000000.pdf)

This article presents a case study where the use of a permeable reactive barrier and a pump and treat technology are compared at manufactured gas plant site in Germany. A life cycle assessment is used to compare these two technologies.

Federation of Canadian Municipalities (FCM) Case Studies. *Brantford Soil Remediation Demonstration Project - Greenwich Mohawk Brownfield Site*. (2012) (http://www.fcm.ca/home/programs/green-municipal-fund/funded-initiatives.htm?lang=en&project=e7eb026d-c590-e111-9d21-005056bc2614&srch=brownfield)

The City of Brantford is testing an in situ, heat-enhanced soil remediation technology on a portion of its 52-acre Greenwich Mohawk brownfield site. The field test will target the removal of petroleum hydrocarbons from a 300 m2 area that is the source of an important groundwater contamination plume. The treatment process injects hot steam into the soil through injection wells. The mobilized contaminants are extracted with a vacuum system; then condensed, separated and disposed of as chemical waste. This process can be conducted without demolishing existing infrastructure, which would allow the city to preserve heritage buildings on site during the eventual full-scale remediation. The test results will be compared to ex situ remediation methods using a triple-bottom line approach.

Federation of Canadian Municipalities (FCM) Case Studies. *Photoremediation Field Test in an Urban Setting at the Monsabré Community Garden in Montréal*. (2013) (http://www.fcm.ca/home/programs/green-municipal-fund/funded-initiatives.htm?lang=en&project=2c1de87a-da6e-e211-820e-005056bc2614&srch=brownfield)

The Institut de recherche en biologie végétale (IRBV), in partnership with the Montréal Botanical Garden, is conducting experiments on phytoremediation to prove the viability and profitability of this technique on both an environmental and economic level. Several plant species are being evaluated to determine their ability to remediate the site. The biomass is being harvested and converted to biofuels and bioproducts. In addition to reducing operation and maintenance costs when compared to other treatment methods, phytoremediation also has numerous environmental benefits: capturing greenhouse gases, reducing heat islands, reducing transportation-related emissions associated with shipping contaminated soils to landfills, etc.

Higgins. M.R. and T.M. Olson. *Life-Cycle Case Study Comparison of Permeable Reactive Barrier versus Pump-and-Treat Remediation in Environmental Science and Technology*. (2009) (http://pubs.acs.org/doi/abs/10.1021/es9015537)

In this article permeable reactive barrier (PRB) technology is compared with a conventional pump-and-treat system using a life-cycle assessment (LCA). This assessment is used to determine if the greater material production requirements to install PRBs may offset the expected reductions in operational phase impacts. The life-cycle environmental impacts of a zerovalent iron (ZVI) containing PRB with a funnel and gate configuration and pump and treat are compared in a case study. This study showed that, even at conservatively low estimates of longevity, the PRB offers significant environmental advantages in impact categories of human health and ozone depletion. Suggested PRB design innovations to reduce environmental impacts include the development of alternative reactive media and construction methods.

Minnesota Pollution Control Agency. *Toolkit for Greener Practices - Showcase of Ideas - Option 1-1: In - Situ Treatment - Reagent Injection - Source Area*. (no date) (http://www.pca.state.mn.us/index.php/view-document.html?gid=11803)

Contamination at this site resulted from a major release of chlorinated solvents to ground water from a former plating shop. Impacts (primarily trichloroethene (TCE)) in the source area extended below the water table. A pilot project for in-situ treatment of TCE was performed and found that the injection of a potassium permanganate reagent would break down the TCE into non-

hazardous byproducts. From a sustainability point of view, reagent injection is a low-energy alternative that shows promise for addressing high groundwater concentrations at the source.

Minnesota Pollution Control Agency. *Toolkit for Greener Practices - Showcase of Ideas - Option 1-2: Innovative and More Efficient Remedies - Ground Water Treatment Through a Restored Wetland.* (no date)
(http://www.pca.state.mn.us/index.php/view-document.html?gid=11804)

At this site, ground water was contaminated with chlorinated solvents from a degreasing operation at a former manufacturing plant. The preferred remedy involved restoring a former lakeshore wetland that had been channelized to accommodate residential development in the early 1900s. Natural attributes of the restored wetland would treat the groundwater plume that discharged into the channelized area formerly occupied by the wetland. The sustainability benefits of this approach were that the selected remedy enhanced the natural environment, the pre-1900s wetland was restored, minimal mechanical/equipment disruptions, low energy requirements and no chemical injected into the ground water.

Minnesota Pollution Control Agency. *Toolkit for Greener Practices - Showcase of Ideas - Option 1-3: Constructed Wetland - Anoka Closed Landfill Groundwater Treatment. (no* date)
(http://www.pca.state.mn.us/index.php/view-document.html?gid=11805)

This site is a former municipal sanitary landfill with a large groundwater plume contaminated with volatile organic compounds (VOCs) at depths of up to 100 feet below the surface. In 1991, two air-stripping towers were installed that discharges up to 300 million gallons of treated water into the Mississippi River annually, lowering the groundwater table and destroying wetlands on site. Additionally, the air-stripping towers were underperforming, calling for additional remedial action, which resulted in the development of a constructed cascade and wetland system. The sustainability benefits of this system are that the water is conserved thus protecting the groundwater and the wetlands and enhancing the habitat. As well, the potential lifetime energy savings are very large.

Sustainable Remediation Forum (SuRF) UK. *SuRF UK Bulletin - Sustainability Assessment: Shell Terminal Facility, Madeira.* (2013)
(http://www.claire.co.uk/index.php?option=com_phocadownload&view=category&download=365:surf-case-study-1&id=16:surf-uk-bulletins&Itemid=230)

A sustainable remediation assessment was applied in this project. This assessment compared ex-situ thermal desorption process to in-situ enhanced bioremediation. The bioremediation option was chosen based on the following sustainability benefits:

- A reduction in CO2 emissions due to less intensive energy use;
- A reduction in costs;
- A reduction in fuel use;
- A reduction in neighbourhood disturbance caused by noise, which would have arisen from the operation of the thermal desorption plant; and
- Potential for local employment.

Tajam, J.A. et al. *Small Scale In-Situ Bioremediation of Diesel Contaminated Soil – Screening LCA of Environmental Performance*, in International Conference on Natural Sciences and Technologies for Waste and Wastewater Treatment, Remediation, Emissions Related to Climate, Environmental and Economic Effects. (2010)
(http://swepub.kb.se/bib/swepub:oai:DiVA.org:miun-12255?tab2=abs&language=en)

This paper provides a LCA for the use of enhanced bioremediation of diesel contaminants in soil using whey, a byproduct from cheese production. Using an actual diesel contamination site as a case study, a screening life cycle assessment model was used. The goal of the study was to investigate the environmental performance of the whey method, and compare it with excavation and composting. Results from the screening life cycle assessment indicate a good environmental performance of the whey method and concluded that the whey on-site treatment could be an interesting alternative for bioremediation especially at sites that would not otherwise be treated, due to small size or remote location.

Groundwater Pump and Treat Optimization - References (Section 8.1.5)

General Guidance

U.S. Environmental Protection Agency (U.S. EPA). *Green Remediation BMPs: Pump and Treat Technologies*. (2009)
(https://clu-in.org/greenremediation/)

The US EPA best management practice (BMP) fact sheets are intended to help project managers and other stakeholders apply the principles on a routine basis, while maintaining the cleanup objectives, ensuring protectiveness of a remedy, and improving its environmental outcome. This factsheet covers sustainability approaches related to the use of pump and treat during remediation projects.

U.S. Environmental Protection Agency (U.S. EPA). *Profiles of Green Remediation (Water)*. (no date)
(https://clu-in.org/greenremediation/tab_d.cfm)

This US EPA site provides a table of several sustainable remediation case studies and indicates the best management practices used in them. This profile highlights techniques for water use reduction. Included in the descriptions are innovative technologies and novel field methods.

9 Confirmatory Sampling and Final Reporting / Long-term Monitoring (FCSAP Steps 9 and 10)

9.1 Sustainable Best Management Practices

Confirmatory Sampling and Final Reporting / Long-term Monitoring (FCSAP Steps 9 and 10) Sustainable Best Management Practices	LEVEL 1*	LEVEL 2*
9.1.1 Sustainable Site Confirmatory Sampling / Monitoring (References) Plan and implement site monitoring methods that reduce energy and waste generation, where possible, while still providing the necessary due diligence. Sustainable site monitoring methods to consider include:	X	X
• Use on-site analytical techniques to avoid long-distance transportation of samples to laboratories,	X	X
• Use passive analytical devices that avoid the need for digging wells and bore holes,	X	X
• If wells / boreholes are required, use drilling / digging techniques that reduce waste generation, such as low flow purge techniques for groundwater sampling,	X	X
• If sampling is required, develop a strategic sampling plan and use statistical methods to avoid over sampling of the site,		X
• Use telemetry or remote data collection.		X
9.1.2 Sustainable Contracting Methods (References) Develop use sustainable contracting clauses as outlined in the Environmental Procedures in Section 01-35-43 of the Public Works and Government Services Canada's National Master Specification.	X	X
9.1.3 Sustainable Approaches Profiling Report on and profile the use of sustainable approaches at the site.		X

* Notes
Level 1 = Simple sustainable activities and qualitative analyses that can be applied at smaller, less complex sites.
Level 2 = Multifaceted sustainable activities and more robust and defensible quantitative analyses that can be applied at larger or more complex sites.

Appendix B: Site Management Options Assessment

This appendix discusses methods for assessing the relative advantages and disadvantages of a variety of remediation or risk management (R/RM) options.

Part 1 – The Theory

Role of cost/benefit analysis

Cost/benefit analysis is a commonly accepted approach for determining the feasibility of various alternatives being considered to address a particular problem or project requirement. In the context of contaminated sites, this can be used as a basis to determine the optimum approach where a variety of alternatives exist to address site conditions, representing a range of effectiveness, implementability and cost considerations.

In order to conduct the cost/benefit analysis, it is typically necessary to determine the alternatives for consideration, identify the evaluation criteria to be applied, and then conduct the comparative evaluation using an appropriate method. This is discussed in more detail below.

Development of an alternatives array

The formulation of a range of alternatives can be illustrated in an array that identifies the technical options available for addressing the site conditions (identified prior to Step 7). This may include both remediation and risk management techniques, and a combination depending on the site-specific circumstances and the environmental media that need to be addressed.

For illustration purposes, an example alternatives array is included in Table 1. As shown in the table, a total of nine alternatives are included. Each alternative includes specific actions related to individual site-specific areas or units (e.g., equipment/storage vessels, waste disposal areas, impacted soil areas, impacted groundwater areas). The scope of the alternatives progress sequentially from "do nothing," to limited action (waste material removal, access restrictions, monitoring), then containment, and finally to active remediation through treatment. The potential application of both risk management and remediation methods is an integral part of the array, and a variety of other combinations may be available beyond what is shown in this example. In carrying out the comparative assessment, it may ultimately be decided that the optimum alternative is a refinement of the alternatives initially included in the array. The evaluation process should provide flexibility for this type of decision making.

It is noted that Alternative 1 (no action) may appear inherently unacceptable at the outset. However, its inclusion in the array may be useful for representing a baseline condition to identify the consequences of "do nothing" and for assisting with the justification for selecting one of the other alternatives.

Table 1
Example Alternatives Array
Cost/benefit analysis for remediation/risk management alternatives for federal contaminated sites

Area/Unit	1	2	3	4	5	6	7	8	9
Drums/tanks/ piping	No action	Remove	Remove	Remove	Remove	Remove	Remove	Remove	Remove
Waste disposal pit	No action	Restrict access	Cap	Cap	Excavate/dispose	Excavate/dispose	Excavate/dispose	Excavate/dispose	Excavate/dispose
Soil impacted above industrial use guidelines	No action	Restrict access	Cap	Cap	Cap	Cap	Excavate/dispose/treat	Excavate/dispose/treat	Excavate/dispose/treat
Soil impacted above unrestricted use guidelines	No action	Restrict access	Restrict access	Restrict access	Restrict access	Restrict access	Restrict access	Cap	Excavate/dispose/treat
Groundwater at source area	No action	Monitor	Monitor	Treat-ment	Treat-ment	Treat-ment	Treat-ment	Treat-ment	Treat-ment
Groundwater plume	No action	Monitor	Monitor	MNA*	MNA	Treat-ment/ MNA	Treat-ment/ MNA	Treat-ment/ MNA	Treat-ment/ MNA

**MNA: monitored natural attenuation*

Potential evaluation criteria

In most situations, the comparative evaluation of alternatives relies on the use of criteria against which each alternative can be assessed relative to other alternatives. These criteria may be either qualitative or quantitative, and will generally consider factors relating to overall protection, effectiveness, implementability, cost, stakeholder considerations and regulatory compliance. A list of potential evaluation criteria is included in Table 2. As shown in the table, various criteria may be applicable under each category, and are further classified according to the type of criteria (threshold, balancing and acceptance).

Table 2
Potential Evaluation Metrics
Cost/benefit analysis for remediation/risk management alternatives for federal contaminated sites

CATEGORY/EVALUATION METRICS	METRIC TYPE		
Overall protection	**Threshold**	**Balancing**	**Acceptance**
Protection of human health	X		
Protection of the environment	X		
Effectiveness	**Threshold**	**Balancing**	**Acceptance**

CATEGORY/EVALUATION METRICS	METRIC TYPE		
Short-term effectiveness		X	
Long-term effectiveness and permanence		X	
Reduction of toxicity, mobility, volume		X	
Implementability	**Threshold**	**Balancing**	**Acceptance**
Use of proven technology		X	
Use of innovative technology		X	
Use of sustainable construction/remediation methods		X	
Permits and approvals required		X	
Time required for implementation		X	
Impacts and risks to the environment		X	
Impacts and risks to the public and workers		X	
Cost	**Threshold**	**Balancing**	**Acceptance**
Construction cost		X	
Operation and maintenance cost		X	
Decommissioning cost		X	
Present worth cost		X	
Stakeholder considerations	**Threshold**	**Balancing**	**Acceptance**
Federal government/custodian acceptance			X
Provincial government acceptance			X
Local government acceptance			X
Community/public acceptance			X
Regulatory compliance	**Threshold**	**Balancing**	**Acceptance**
Compliance with regulatory requirements – federal	X		
Compliance with regulatory requirements – provincial	X		
Compliance with regulatory requirements – local	X		
Other	**Threshold**	**Balancing**	**Acceptance**
Sustainable development		X	
Future development potential		X	
Long-term liability		X	
Impact on land value		X	
Impacts on future operations		X	
Compatibility with federal government policies			X

CATEGORY/EVALUATION METRICS	METRIC TYPE		
Socio-economic impacts		X	

Threshold criteria include minimum requirements that need to be met in order for the alternative to be considered for selection. Typically, this relates to protection of human health and the environment, and regulatory compliance. Alternatives that satisfy these threshold criteria will be suitable for passing an initial screening and then short-listed for more detailed consideration.

Balancing (or modifying) criteria are those which are used to compare the relative merits of the various alternatives and associated trade-offs. For example, Alternative A might be expected to achieve a permanent solution and unrestricted future site use, whereas other alternatives may achieve an acceptable cleanup level for commercial or industrial site use at a much lower cost.

Acceptance criteria are those that relate to meeting the expectations of various stakeholder groups, including various levels of government and the local community. Acceptance considerations may ultimately be used to make a final selection from a list of several otherwise suitable alternatives, or as a basis for refinement of a preferred alternative.

An alternative that is preferable based on balancing criteria considerations may not ultimately be selected for implementation if it is not acceptable to stakeholders. In some cases (e.g., large/complicated sites), stakeholder input will probably have already been considered in developing the list of alternatives.

The list shown in Table 2 represents potential criteria for consideration. The selection of relevant criteria may be affected by site-specific factors, and it may be decided that some should be deleted, or others added, as necessary and appropriate.

Options for comparative evaluation of alternatives

A variety of methods are available for conducting a comparative evaluation of alternatives in order to identify the most suitable alternative (and hence site management strategy) for implementation. This includes the following examples described herein: ad hoc methods, checklist methods, economic methods, pairwise comparison methods and matrix methods.

Ad hoc methods compare alternatives in narrative terms without using any explicitly stated methods to order the preferences, based on professional judgment. Typically, the use of ad hoc methods, as the name implies, does not necessarily follow an explicit set of evaluation criteria. This approach can be applied to situations in which the scope of the problem is narrow and well defined, and the rationale for selection of the proposed alternative can be readily communicated. However, in more complex situations this method is subject to potential problems such as assuring that each alternative is evaluated in a consistent manner.

Checklist methods compare and evaluate alternatives against a specified set of criteria with no compensatory rules or tradeoffs. Typically, this involves posing a series of questions related to the individual criteria that require a yes or no response, such as:

- Is the alternative protective of human health and the environment?
- Is the alternative effective in the long term?

- Does the alternative use proven methods or technology?
- Is the estimated cost below a defined threshold?

This approach may be useful for identifying dominant alternatives for screening purposes. For example, if Alternative A is better than Alternative B in at least one respect and no worse than Alternative B in any other respect, Alternative A may be considered dominant.

Economic methods use economic procedures and principles to translate non-commensurable units into monetary units. This methodology relies largely on determining an individual's willingness-to-pay (the amount that individuals affected by the project would be willing to pay for the defined benefits), and the availability of market prices that relate to the benefits. By their nature, many of the benefits associated with environmental improvements cannot be readily determined based on market prices; however, this type of method may have application in situations where the property is being considered for sale and/or redevelopment. In this case, it may be possible to directly relate the cost of implementing an alternative to the beneficial value of land improvement.

Pairwise comparison methods use the sequential comparison of alternatives in pairs as a basis for subsequent ordering of preferences. In its simplest form, the procedure develops a measure of how frequently one alternative is superior to another based on the various evaluation criteria. This is improved using **fuzzy set procedures**, which is based on subjective interpolation, and is used to identify inefficient alternatives (those that are dominated by other alternatives). In this case, each alternative is numerically ranked for each evaluation criteria. Initially, two alternatives are compared to determine dominance, i.e., which of the two alternatives has the greater number of occasions of dominance. The dominant alternative is then compared to the next alternative, and so on, until one dominant alternative is identified. The method can be based on either a non-parametric or parametric ranking; however, in both cases, the assignment of the ranking values may be subjective. Also, the relative importance of each criterion is not reflected in the procedure unless the criteria are ranked into groups.

Matrix methods use a matrix for the summary, comparison and evaluation of criteria and alternatives, based on professional judgment (as an extension of ad hoc methods). In this case, weight factors are applied to each evaluation criterion to reflect its overall importance, and ranking factors are applied to each alternative (for each criterion). These are multiplied and summed to develop an overall score. In this manner, alternatives that score well can be considered to be superior to other alternatives. This method relies on subjective assignment of the weight and ranking factors, and therefore would need to be supported by the assessor's justification for assigning the factors. It is an improvement over ad hoc methods in that all evaluation criteria need to be considered for each alternative, and it is amenable to sensitivity analysis by examining the effects of changes in the factors. Both the pairwise comparison and the matrix methods are transparent in the identification of the preferred alternative and hence potentially very useful in public consultation.

Expert support tools that may assist the custodian in completing the preceding evaluation include the **Guidance and Orientation for the Selection of Technologies (GOST)** and the **Sustainable Development Tool (SDT)**. GOST is a technology database that contains individual fact sheets on a host of treatment technologies/approaches. The user is prompted for a series of inputs regarding contaminant and site data (e.g., hydro-geologic conditions), which results in the identification of a number of technically feasible R/RM options. Custodians could consider the use of GOST as early as Step 5 and during Step 7 of the 10-step federal process, primarily to identify potential candidate technologies/approaches for management of their sites.

A secondary benefit of GOST is that it provides assistance to the custodian in confirming the necessary data to be collected during the environmental site assessment (ESA), via the required inputs to the model, to support this evaluation.

Once the custodian has identified a suite of potential technologies/approaches using GOST, a secondary evaluation can be conducted using SDT to evaluate and compare up to five separate treatment options from the perspective of the three pillars of sustainability: economic, social and environmental. Custodians can choose from a suite of parameters for all three elements—and further, use weightings for each parameter—to reflect their specific site situation. The output from the model is both graphical and numerical, such that it serves as a communication as well as an analytical tool. This approach allows for stakeholder engagement and incorporation of multi-stakeholder requirements. The intent is that custodians will select the most balanced alternative with the cost in mind; SDT will help them to incorporate sustainability aspects into their evaluation process when identifying the preferred alternative.

Part 2 – Example Alternatives Assessment

An example of alternatives assessment using the pairwise comparison and matrix methods based on a contaminated site scenario is presented below.

Use of evaluation metrics to select the preferred remediation/risk management (R/RM) alternative

Table 2 includes the potential evaluation metrics within various categories that can be used as part of the process for identifying the preferred R/RM alternative. Although Table 2 lists a number of evaluation metrics associated with each category, not all evaluation metrics will be employed in an actual evaluation. In practice, it is only necessary to employ the evaluation metrics that are relevant to discriminating between the R/RM alternatives. Hence, only a subset of the potential evaluation metrics will be employed in any particular evaluation.

As apparent from the list of potential evaluation metrics, individual metrics are not measured using the same units, and hence they are not additive. As a result, they cannot be combined in a simple manner. Instead, a means of combining the value of an alternative must be made relative to the various evaluation metrics, to determine which of the alternatives is preferred.

An additional dimension of the evaluation criteria must also be acknowledged; if an alternative does not attain a threshold (e.g., with respect to human health and the environment), that alternative is not acceptable and is not considered beyond the first level of analysis.

Example problem definition

The following example demonstrates how the methodology is applied. Please note that this problem situation has been kept fairly simple in order to focus on the methodology rather than on precise complexities that may arise in practice. Furthermore, the exact details of the preferred strategy are not supplied but are assumed to be consistent with good practice, specifically for a remote site.

Consider the following situation:

A waste disposal pit and an underlying groundwater plume have been identified at a site. The alternatives for the remediation of the disposal pit were identified as capping the pit, or excavation and disposal of the waste.

For the underlying groundwater plume, the alternatives that will be considered are monitored natural attenuation (MNA) and groundwater treatment with MNA combined (treatment/MNA). The duration of these options will vary, since treatment will promote a more rapid reduction in contaminant concentrations. The status quo ("do nothing") option associated with the groundwater plume should also be considered, as there may be no need to undertake action, and it will provide a baseline for comparison of this scenario.

The individual alternatives, as classified into vertical sets of options, are illustrated in Table 3. Other options may be available, for example cap and treatment/MNA, but are not included in this example in order to maintain simplicity.

Table 3
List of Alternatives

Area/Unit	*EXC**	*1*	*2*	*3*
Waste disposal pit	No action	Cap	Excavate/dispose	Excavate/dispose
Groundwater plume	No action	MNA	MNA	Treatment/MNA

**EXC: excluded as a viable alternative as it does not attain the necessary threshold levels.*
**MNA: monitored natural attenuation*

These alternatives include elements related to both risk management (i.e., cap and MNA) and remediation (i.e., excavate/dispose and groundwater treatment/MNA). We are now interested in selecting the preferred alternative, where the preferences between the options regarding long-term effectiveness may be different, for example, than cost considerations.

To proceed to the next step, each of the alternatives needs to be considered with respect to each of the evaluation criteria within the categories. This step is accomplished in the following sub-tables, as follows:

(i) The alternative is judged to be unacceptable or excluded in terms of threshold levels and, hence, is no longer considered.
(ii) Table 4(a) summarizes the attributes of each of the alternatives relevant to effectiveness. It should be noted that the only relevant effectiveness evaluation criteria are the long-term effectiveness and the reduction of toxicity, mobility or volume.

Table 4(a)
Description of attributes of alternatives related to effectiveness criteria

Alternative	*Long-term effectiveness*	*Reduction of toxicity, mobility or volume*
1. Capping and MNA	Capping not necessarily effective in the long term, and attenuation of groundwater contamination will occur but will take some time.	There will be no reduction of toxicity, mobility or volume of chemicals within the waste disposal pit contents, and reduction of groundwater contamination will occur over time.
2. Excavation/disposal and MNA	This represents a permanent solution for in situ wastes, and attenuation of groundwater contamination will occur but will take some time.	This will reduce/eliminate the waste disposal pit contents, and will result in attenuation of the groundwater contamination over time.
3. Excavation/disposal and treatment/MNA	This represents a permanent solution for in situ wastes, and will result in attenuation of groundwater contamination more rapidly than MNA alone.	This will reduce the toxicity of waste pit contents, and will result in attenuation of groundwater contamination more rapidly than MNA alone.

**MNA: monitored natural attenuation*

(iii) Table 4(b) summarizes the attributes of each of the alternatives relevant to "implementability." All of the alternatives involve the application of proven technologies, none are innovative, all involve the necessity to obtain permits, etc. This means that the discriminating factor between the alternatives is the time required for implementation (e.g., MNA requires a lengthy period for site remediation whereas capping is implemented relatively quickly). Impacts and risks to the environment during implementation must also be a consideration (i.e., consider the risks associated with the transport and disposal of the excavated material).

Table 4(b)
Description of attributes of alternatives related to implementability criteria

Alternative	*Time required for implementation*	*Impacts and risks to environment*
1. Capping and MNA	Rapid to construct cap. MNA will take time to be totally effective.	Technology of capping is understood, and risks to environment by MNA are small, although the possible ongoing source of contamination must be considered.
2. Excavation/disposal and MNA	Excavation/disposal relatively rapid. MNA will take time to be totally effective.	May be issues in relation to contaminant release during excavation as well as at the disposal site. MNA risks are small.

Alternative	*Time required for implementation*	*Impacts and risks to environment*
3. Excavation/disposal and treatment/MNA	Excavation/disposal relatively rapid. Treatment/MNA will be more rapid than MNA alone.	May be issues in relation to contaminant release during excavation. Treatment/MNA risks are small and less than MNA alone.

(iv) Table 4(c) describes the attributes of the various alternatives in terms of costs. In this application, the costs are determined in terms of present worth (or net present value) and therefore show the combination effect of construction costs, operation and maintenance costs, and discount rate.

Table 4(c)
Description of attributes of alternatives related to cost criteria

Alternative	*Magnitudes of costs of each alternative*
1. Capping and MNA	2 million + 1 million = 3 million
2. Excavation/disposal and MNA	10 million + 1 million = 11 million
3. Excavation/disposal and treatment/MNA	10 million + 2 million + 0.5 million = 12.5 million

(v) Table 4(d) describes the attributes for different alternatives in terms of the "Other" category. This may be a relevant consideration in selecting between the alternatives in that there is long-term liability for ensuring that MNA functions as intended, as opposed to, for example, the excavation and destruction of the wastes. For MNA, there is some degree of long-term liability associated with the site. Also, the potential impacts on future site operations may be a consideration.

Table 4(d)
Description of attributes of alternatives related to other evaluation criteria

Alternative	*Magnitudes of long-term liability*	*Impacts on future operations*
1. Capping and MNA	***Liability*** exists since capping does not destroy the contaminants, and the time for MNA to be effective is potentially long.	***Operations:*** Capping will limit certain land-use activities on site.
2. Excavation/disposal and MNA	Reduced long-term liability since the remediation removes the contaminants, although time for MNA to be effective may still be prolonged.	Excavation/disposal will allow future land uses depending on residual contaminant concentrations.
3. Excavation/disposal and treatment/MNA	Minimum long-term liability since the remediation removes the contaminants and time for treatment/MNA is shorter.	Excavation/disposal will allow future land uses depending on residual contaminant Concentrations.

The set of Tables 4(a) through 4(d) summarizes how the alternatives are measured with respect

to each of the evaluation criteria. The next stage is to identify which of the alternatives is/are the preferred alternative(s). This will be accomplished using the two separate procedures designed for this identification, namely (i) the pairwise comparison method and (ii) matrix weighting procedures.

Identification of preferred alternative

Using the pairwise comparison method

Table 5
Comparison of Alternatives 1 and 2

Category/Evaluation Criteria	*Preferred Alternative*	*Rationale*
Effectiveness		
Long-term effectiveness	2	Alternative 2 is more effective since it removes the waste material.
Reduction of toxicity, mobility or volume	2	Alternative 2 is more effective since it removes the waste material.
Implementability		
Time required for implementation	1	Alternative 1 requires less time for implementation and avoids potential
Impacts and risks to the environment	1	Alternative 1 requires less time for implementation and avoids potential
Costs	1	Alternative 1 involves lower cost.
Other		
Long-term liability	2	Alternative 2 reduces long-term liability associated with leaving the waste in place.
Impacts on future operations	2	Alternative 2 reduces long-term liability associated with leaving the waste in place.

Alternative 2 has four evaluation criteria in which it is preferred to Alternative 1, and there are three criteria in which Alternative 1 is preferred to Alternative 2. In this situation, Alternative 2 moves on to be compared with Alternative 3. It is noted that this comparison suggests that there is little difference between Alternatives 1 and 2.

In a more complete assessment of impacts, other considerations such as off-site impacts like transportation of excavated material and liability/risk associated with disposal might also be evaluated with regard to each alternative. Please note this type of evaluation does not give weight to the evaluation criteria; it only allows a preference for one alternative method or another. A weighted matrix example is explained later in this appendix.

Table 6
Comparison of Alternatives 2 and 3

Category/Evaluation Criteria	*Preferred Alternative*	*Rationale*
Effectiveness		
Long-term effectiveness	3	Alternative 3 is more effective since it reduces the contaminant mass through treatment.
Reduction of toxicity, mobility, or volume	3	Alternative 3 is more effective since it reduces the contaminant mass through treatment.
Implementability		
Time required for implementation	3	Alternative 3 requires less time to reach acceptable contaminant levels because
Impacts and risks to the environment	3	Alternative 3 requires less time to reach acceptable contaminant levels because
Costs	2	Alternative 2 involves lower cost.
Other		
Long-term liability	3	Alternative 3 shortens the time that groundwater contamination persists.
Impacts on future operations	No Difference	--

In this comparison, Alternative 3 is preferred to Alternative 2 with regard to five evaluation criteria, whereas Alternative 2 is preferred to Alternative 3 in only one criterion. This indicates that Alternative 3 is the preferred alternative remediation option.

Based on the above, it could be concluded that Alternative 3 is the preferred alternative, if all evaluation criteria were considered to have equal weight (or importance), as is the case with this method. Weightings are applied in the matrix method discussed below.

Using Matrix Weighting Procedures

Two sets of weighting factors are required:

- The factor weights for the evaluation criteria within each category, where the sum of the factor weights equals one. For example, within the effectiveness category there are two evaluation criteria (long-term effectiveness and reduction of toxicity, mobility or volume), each of which is assigned a factor weight.
- The priority group weights, to reflect the relative importance of each category and assign values such that the sum of the priority group weights equals one. In this case, each of the four categories (effectiveness, implementability, cost, other) is assigned a priority group weight.

The selection of the weighting factors needs to consider the viewpoints of the interested parties, recognizing that different stakeholders may be more sensitive to specific evaluation criteria than others. However, the procedure does allow sensitivity testing to determine differences in the analysis resulting from changes in the weight factors.

Ranking of one alternative relative to another

In the example matrix, each of the alternatives is ranked relative to the others using non-parametric means, such that the best of the three alternatives associated with each of the evaluation criteria receives a 3, the second-best gets a 2, and the third-best gets a 1. In the event of a tie, the average of the two is assigned to both.

Simple matrix weighting calculations are summarized in the table below, which shows that Alternative 3 is the preferred alternative of the three (i.e., has the highest score).

Table 7
Scoring calculation for alternatives using matrix weighting procedure

Category/Evaluation Criteria	*Factor Weight*	*Ranking Score Alternative (1, 2, 3)*			*Weighted Factor*			*Priority Group Weight*	*Weighted Factor Alternative (1, 2, 3)*		
Effectiveness											
Long-term effectiveness	0.7	1	2	3	0.7	1.4	2.1				
Reduction in toxicity	0.3	1	2	3	0.3	0.6	0.9				
				Total Weighted Factor	1	2	3	**x 0.2**	0.2	0.4	0.6
Implementability											
Time required	0.5	3	1	2	1.5	0.5	1				
Impacts of risks	0.5	1	2	3	0.5	1	1.5				
				Total Weighted Factor	2	1.5	2.5	**x 0.3**	0.6	0.45	0.75
Cost											
Present worth	1	3	2	1	3	2	1				
				Total Weighted Factor	3	2	1	**x 0.3**	0.9	0.6	0.3
Other											
Long-term liability	0.7	1	2	3	0.7	1.4	2.1				
Impacts on future operation	0.3	1	3	2	0.3	0.9	0.6				
				Total Weighted Factor	1	2.3	2.7	**x 0.2**	0.2	0.46	0.54
								Final Alternative Score	1.9	1.91	2.19

**Note: red numbers refer to Alternative 1; blue numbers refer to Alternative 2; and purple number refers to Alternative 3.*

Ranking of each alternative on a scale of one to ten

Another option is to rank the values on a scale from one to ten using parametric means. This allows the assessor to determine, for example, the magnitude of the differences between the alternatives for individual evaluation criteria.

Additional considerations

The example problem was kept very simple to allow the primary focus to be on the selection procedure for the preferred alternative. However, it should be clear that the process may be considerably more complex in a real situation. Examples of the challenges that could arise

include the following:

- There may be more than one evaluation criteria necessary to discriminate between the preferred alternatives in a particular application. For example, there could be both long- and short-term differences in the effectiveness of different alternatives. In this situation, and if both long- and short-term ramifications are better for Alternative A in comparison with B, the approach is relatively simple in that both could be combined into a single metric by which the alternatives can be compared. The challenge will be where Alternative A is better than B with respect to short-term effectiveness, and B is better than A with respect to long-term effectiveness. In this situation, it may be necessary to employ the preferred alternative within an individual category first, and then proceed to the next level of assessment.

- The procedures are readily transparent and are apparent to reviewers. Hence, discussion on the assignments can be focused on points of controversy, should they exist.

The procedures are straightforward to apply and test the sensitivity of the selection by allowing different methods to arrive at the same conclusion.

There is merit in completing evaluations using one or more procedures, for example pairwise comparison or matrix weighting comparisons; if the results are the same, it demonstrates that the findings are robust

List of Abbreviations

Abbreviation	Definition
ASCS	Aquatic Site Classification System
CCME	Canadian Council of Ministers of the Environment
CEAA	*Canadian Environmental Assessment Act*
CEPA	*Canadian Environmental Protection Act, 1999*
CSA	Canadian Standards Association
CSM	Conceptual Site Model
DFO	Fisheries and Oceans Canada
DMF	Decision-Making Framework
DQRA	Detailed Quantitative Risk Assessment
ECCC	Environment and Climate Change Canada
EA	Environmental Assessment
ERA	Ecological Risk Assessment
ESA	Environmental Site Assessment
FCSAP	Federal Contaminated Sites Action Plan
FCSI	Federal Contaminated Sites Inventory
GOST	Guidance and Orientation for the Selection of Technologies
HC	Health Canada
HHRA	Human Health Risk Assessment
IDEA	Interdepartmental Data Exchange Application
INS	Insufficient information
LTM	Long-term monitoring
MNA	Monitored natural attenuation
NCSCS	National Classification System for Contaminated Sites
PAT	Priority Assessment Tool

Abbreviation	Definition
PQRA	Preliminary Quantitative Risk Assessment
PSPC	Public Services and Procurement Canada
QA/QC	Quality assurance/quality control
R/RM	Remediation/risk management
RAP	Remedial Action Plan
RMP	Risk Management Plan
RMS	Risk Management Strategy
SARA	*Species at Risk Act*
SCT	Site Closure Tool
SDT	Sustainable Development Tool
SOW	Statement of Work
SSTL	Site-specific target levels
TB	Treasury Board of Canada
TBS	Treasury Board of Canada Secretariat
TRAV	Tool for Risk Assessment Validation

Reference List

Canadian Council of Ministers of the Environment

Document:	Also mentioned in:
Introduction	
Guidance Document on the Management of Contaminated Sites in Canada (CCME, 1997)	
Step 3	
Canadian Environmental Quality Guidelines • A Protocol for the Derivation of Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007) • A Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006) • A Protocol for the Derivation of Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (CCME, 1995) • A Protocol For The Derivation Of Groundwater Quality Guidelines For Use At Contaminated Sites (CCME, 2015)	Step 5, Step 7, Step 9
Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume I: Main Report (CCME, 1993)	Step 5, Step 7, Step 9
Guidance Manual on Sampling, Analysis, and Data Management for Contaminated Sites – Volume II: Analytical Method Summaries (CCME, 1993)	Step 5, Step 7, Step 9
Subsurface Assessment Handbook for Contaminated Sites (CCME, 1994)	Step 5
Canada-Wide Standard for Petroleum Hydrocarbons in Soil (CCME, 2008)	Step 5. Step 7
Step 4	
National Classification System for Contaminated Sites Guidance Document (NCSCS) (CCME, 2008)	Step 6
National Classification System for Contaminated Sites Spreadsheet (CCME, 2008)	Step 6
Step 7	
CCME Canadian Environmental Quality Guidelines (website) {*http://www.ccme.ca/en/testscript/cqge-sub.html*}	
Guidance Manual for Developing Site-Specific Soil Quality Remediation Objectives for Contaminated Sites in Canada (CCME, 1996)	
Canada-Wide Standard for Petroleum Hydrocarbons Spreadsheet Model (CCME, 2008-2009)	

Canadian Standards Association

Document:	Also mentioned in:
Step 2	
Canadian Standards Association (CSA) Standards for Phase I Environmental Site Assessments (CSA, 2001)	

Canadian Standards Association (CSA) Standards for Phase II Environmental Site Assessment (CSA, 2004)	Step 3, Step 5

Contaminated Sites Management Working Group

Document:	Also mentioned in:
Introduction	
A Federal Approach to Contaminated Sites (Contaminated Sites Management Working Group, 1999)	
Phase II ESA SOW incorporating Science-based Expert Support Input (A Federal Approach to Contaminated Sites, Appendix C, CSMWG, 1999)	

Environment and Climate Change Canada & the Ontario Ministry of the Environment

Document:	Also mentioned in:
Step 5	
Canada–Ontario Decision-Making Framework (DMF) for Assessment of Great Lakes Contaminated Sediment (ECCC and MOE, 2008)	

Federal Contaminated Sites Action Plan

Document:	Also mentioned in:
Introduction	
FCSAP Guidance Manual (FCSAP, 2010)	
Framework for Addressing and Managing Aquatic Sites under the Federal Contaminated Sites Action Plan (FCSAP, 2011)	Step 1, Step 2, Step 3, Step 4, Step 5, Step 6, Step 7, Step 8, Step 9, Step 10
Eligible Costs Guidance, ver. 5.0 (FCSAP, update in progress)	Step 1, Step 2, Step 3, Step 4, Step 5, Step 6, Step 7, Step 9, Step 10
Priority for Assessment Tool (PAT) (FCSAP; update in progress)	Step 1, Step 2, Step 3, Step 4, Step 5, Step 7, Step 8, Step 9
Step 1	
FCSAP Guidance Document on Statements of Work for Ecological Risk Assessments (ERAs) at Federal Sites (FCSAP, 2011)	Step 3, Step 5, Step 7
FCSAP Operational Guidelines (FCSAP 2016, internal document)	
Step 3	
FCSAP Ecological Risk Assessment Guidance (FCSAP, 2012) • Module 1: Toxicity Test Selection and Interpretation (FCSAP, 2010) • Module 2: Selection or Development of Site-specific Toxicity Reference Values (FCSAP, 2010) • Module 3: Standardization of Wildlife Receptor Characteristics	Step 5, Step 7

(FCSAP, 2012) • Module 4: Causality Assessment: Determining the Causes of Impairment at Contaminated Sites: Are Observed Effects Due to Exposure to Site-Related Chemicals or Due to Other Stressors? (FCSAP, 2013) • Module 5: Defining Background Conditions and Using Background Concentrations (FCSAP, 2015)	
Federal Interim Groundwater Guidelines (FCSAP, 2016) • Federal Interim Groundwater Guidelines Update (FCSAP, 2016)	Step 5, Step 7, Step 9
Statements of Work for Ecological Risk Assessments (ERAs) at Federal Sites (FCSAP, 2011)	Step 7
Step 4	
Aquatic Site Classification System (ASCS) worksheets (FCSAP, 2015)	Step 5, Step 6
Supplemental Guidance for the Scoring of Sites Using the National Classification System for Contaminated Sites (NCSCS) and Aquatic Sites Classification Systems (ASCS) under the Federal Contaminated Sites Action Plan (FCSAP, 2013)	Step 6
Aquatic Site Classification System (ASCS) - Version 3.2 Detailed User Guidance Manual (FCSAP, 2015)	Step 6
Step 6	
Interdepartmental Data Exchange Application (IDEA) (FCSAP)	
Step 7	
Guidance for Site Closure Tool for Federal Contaminated Sites (SCT) (FCSAP, 2012) • Including Tool for Risk Assessment Validation (TRAV)	Step 8, Step 9, Step 10
Federal Guidance for Estimating Remediation Liabilities at Federal Contaminated Sites (FCSAP, 2015)	
Federal Guidelines for Landfarming Petroleum Hydrocarbons Contaminated Soils (FCSAP, 2006, Editorial Update 2013)	Step 8, Step 9, Step 10
FCSAP Long Term Monitoring (LTM) Planning Guidance (FCSAP, 2013)	Step 9, Step 10

Fisheries & Oceans Canada

Document:	Also mentioned in:
Introduction	
Projects Near Water (website) (DFO, 2015)	
Waves: Fisheries and Oceans Canada (DFO) Library (website) (DFO, 2014)	
Step 7	
Fisheries & Oceans Canada (DFO) Pathways of Effects (website) (DFO, 2011)	Step 8

Health Canada

Document:	Also mentioned in:
Step 1	
Addressing Psychosocial Factors through Capacity Building: A Guide for Managers of Contaminated Sites (HC, 2005)	
Improving Stakeholder Relationships: Public Involvement and the Federal Contaminated Sites Action Plan (FCSAP): A Guide for Site Managers (HC, 2006)	
A Guide to Involving Aboriginal Peoples in Contaminated Site Management (HC, 2010)	
Supplemental Guidance on Developing a Contract Statement of Work for Human Health Preliminary Quantitative Risk Assessment (PQRA) and Detailed Quantitative Risk Assessment (DQRA) (HC, 2010)	Step 3, Step 5, Step 7
For Human Health Risk Assessment (HHRA): Federal Contaminated Site Risk Assessment in Canada (available on request from cs-sc@hc-sc.gc.ca): • Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0 (HC, 2012) • Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0 (HC, 2010) • Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0 (HC, 2010) • Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRACHEM) (HC, 2010) • Part VI: Guidance on Human Health Detailed Quantitative Radiological Risk Assessment (DQRARAD) (HC, 2010) • Part VII: Guidance for Soil Vapour Intrusion Assessment at Contaminated Sites (HC, 2010)	Step 3, Step 5, Step 7
Step 3	
Guidelines for Canadian Drinking Water Quality (HC, 2014)	Step 5, Step 7, Step 9
Step 5	
Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRAFoods) (HC, 2010)	
Step 6	
Supplemental Guidance: Checklist for Peer Review of Detailed Human Health Risk Assessment (HHRA) (HC, 2010)	
Step 8	
Remediation Checklist (internal, Health Canada)	

Legislation

Document:	Also mentioned in:
Step 1	
Species at Risk Act (SARA) (2002) • Species at Risk Public Registry	Step 7, Step 8
Fisheries Act (1985)	Step 3, Step 5, Step 7, Step 8
Canada Wildlife Act (1985)	Step 8
Migratory Birds Convention Act (1994)	Step 8

Step 7	
Canadian Environmental Assessment Act (CEAA, 1992 & 2012)	Step 8
Canadian Environmental Protection Act (1999)	Step 8

Public Works Government Services Canada/National Research Council

Document:	Also mentioned in:
Step 3	
Guidance and Orientation for the Selection of Technologies (GOST) (PSPC/NRC, 2012)	Step 7, Step 8

Public Services and Procurement Canada

Document:	Also mentioned in:
Introduction	
Project/Program Risk Management Guidance for Federal Contaminated Sites Remediation/Risk Management (R/RM) Projects (PWGSC, 2007)	Step 8
Step 7	
FCSAP Remediation Conceptual Cost Estimation Tool (PSPC, 2013)	
Sustainable Development Tool [SDT] (PSPC, 2016) Available at: http://sdat.pwgsc.gc.ca	

Treasury Board Secretariat

Document:	Also mentioned in:
Introduction	
Policy on Management of Real Property (TBS, 2006)	
Reporting Standard on Real Property (TBS, 2006)	
Directive on Contingencies (TBS, 2009)	Step 7
Guide to the Management of Real Property (TBS, 2011)	
Federal Contaminated Sites Inventory (FCSI) Input Guide (TBS, 2016)	Step 6, Step 7, Step 9
Step 3	
Policy on Management of Real Property (TBS, 2006)	
Step 6	
Remediation Liabilities Related to Contaminated Sites: A Supplement to the Financial Information Strategy (FIS) Manual	Step 7
Step 7	
Accounting Standard 3.1 – Treasury Board – Capital Assets (TBS, 2001)	
Accounting Standard 3.6 – Treasury Board – Contingencies (TBS, 2006)	

Websites

Title:	Also mentioned in:
Sustainable Remediation Forum (SuRF) Canada = http://www.sustainableremediation.org/	Step 8
Contaminated Site Remediation Projects Roadmap (PSPC)	

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